DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20315

IN REPLY REFER TO

ENGCW-PD

SUBJECT: Beaver Brook Dam and Reservoir, Keene, New Hampshire

TO: THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress the report of the Board of Engineers for Rivers and Harbors, accompanied by the report of the Division Engineer, in response to a resolution of the Committee on Public Works of the United States Senate, adopted 3 October 1960, concerning the advisability of providing flood protection along Beaver Brook, a tributary of the Connecticut River, at and in the vicinity of Keene, New Hampshire.

2. The Division Engineer recommends construction of a multipurpose dam and reservoir on Beaver Brook in Keene, New Hampshire, for flood control, recreation, fish and wildlife enhancement, and future water supply. The total estimated first cost is $1,377,000, of which $819,500 is Federal and $557,500 is non-Federal, after allowing for non-Federal repayment for water supply, recreation, and fish and wildlife enhancement costs. Annual costs for operation, maintenance, and major replacements are estimated at $12,600. Total average annual benefits are estimated at $165,700 and total annual costs are estimated at $57,700, resulting in a benefit-cost ratio of 2.9. The Division Engineer recommends that the project be authorized essentially as set forth in his report, subject to certain conditions of local cooperation.

3. The Board concurs generally in the findings of the reporting officer and recommends construction of the proposed dam and reservoir, subject to local cooperation.

4. I concur in the views and recommendations of the Board.

WILLIAM F. CASSIDY
Lieutenant General, USA
Chief of Engineers

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
BOARD OF ENGINEERS FOR RIVERS AND HARBORS
WASHINGTON, D.C. 20315

IN REPLY REFER TO

ENGBR

22 March 1967

SUBJECT: Beaver Brook Dam and Reservoir, Keene, New Hampshire

TO: Chief of Engineers
Department of the Army

1. Authority.--This report is in partial response to the following resolution adopted 3 October 1960:

> Resolved by the Committee on Public Works of the United States Senate, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 12, 1902, be, and is hereby, requested to review the reports of the Chief of Engineers on the Connecticut River Basin, Vermont, New Hampshire, Massachusetts and Connecticut, published as House Document Numbered 455, Seventy-fifth Congress, second session, with a view to determining whether the recommendations contained therein should be modified in any way at the present time, with particular reference to providing flood protection along Beaver Brook, a tributary of the Connecticut River at and in the vicinity of Keene, New Hampshire.

The report is confined to consideration of the flood and related problems on Beaver Brook at Keene, New Hampshire. A report covering other areas of the Connecticut River basin will be submitted later.

2. Basin description.--Beaver Brook is a small tributary of the Ashuelot River in the Connecticut River basin and drains an area of about 10 square miles at Keene, New Hampshire. The brook flows southward through Keene, joining another tributary

called The Branch, which then discharges within a few hundred feet into the Ashuelot River. Beaver Brook drains parts of the city of Keene and the towns of Gilsum and Sullivan.

3. Economic developments.--The population of the city of Keene, estimated at 18,000 in 1962, is expected to reach 20,000 by 1970. Keene is the market center of a large farming area, and for many years has been a commercial and industrial center for Cheshire County and the western portion of central New Hampshire. Review of statistics for manufactures, retail trade, and population indicates that the city of Keene has accompanied Cheshire County and the State in a steady economic growth over the past three decades. Older industries have held their own or have been replaced by new enterprises. Machine tool and wood products industries have expanded; electronics and plastic plants have moved into the area. Commercial establishments have participated in this growth. The Keene area is served by a network of highways and secondary roads. The main line of the Boston and Maine Railroad and seven trucking lines with four major terminals in Keene provide freight service.

4. Existing improvements.--There are no existing Corps of Engineers or other flood control projects in the Beaver Brook watershed. However, there are two completed flood control projects in the Ashuelot River basin which affect flood stages in the downstream portion of the Beaver Brook watershed: Surry Mountain Dam and Reservoir, on the Ashuelot River, and Otter Brook Dam and Reservoir on Otter Brook. In addition, the authorized (but inactive) Honey Hill Dam and Reservoir project is located on the South Branch of the Ashuelot River south of Keene.

5. Floods and damages.--Flooding on Beaver Brook has been a recurring problem since earliest times. In recent years, eight damaging floods have occurred on Beaver Brook. Under present conditions, a recurrence of the September 1938 flood of record would cause damages in excess of $1,875,000 in the area influenced by Beaver Brook, even with operation of existing reservoirs for flood control. Average annual losses in the reaches of the basin below the proposed Beaver Brook damsite, modified by existing reservoirs, are estimated at $145,000.

6. Improvements desired.--Local interests desire flood protection measures as well as a permanent recreation pool that could be converted later to water supply for the city of Keene. The recommended plan would provide these features. State and local officials and residents of the area have expressed their concurrence with the plan at several meetings, and are willing to cooperate in the improvement.

7. Plan of improvement.--The Division Engineer finds that a plan of improvement for flood control and allied purposes is economically justified. His proposed plan consists of a multipurpose dam and reservoir on Beaver Brook providing flood control storage, a permanent pool for recreation including fish and wildlife conservation, and minimum provisions for future water supply. The principal construction features include a rolled earthfill dam, a concrete chute-type spillway, uncontrolled outlet works, highway relocation, water supply intakes, and a water control structure.

8. Economic evaluation.--Using 1966 price levels, the Division Engineer estimates the cost of the proposed plan of improvement at $1,377,000 for construction, exclusive of preauthorization study costs. Of this amount, $819,500 is the net Federal construction cost and $557,500 is the non-Federal cost. Annual costs for operation, maintenance, and major replacements are estimated at $12,600. Project costs have been allocated to the purposes of flood control, recreation, and water supply. A summary of economic data follows:

Purpose	Allocated first cost	Annual charges	Annual benefits	Benefit-cost ratio
Flood control	$ 599,000	$23,300	$113,600	4.9
Recreation	464,000	22,300	32,000	1.4
Water supply	314,000	12,100	20,100	1.7
Total	$1,377,000	$57,700	$165,700	2.9

Interest and amortization charges are based on an interest rate of 3-1/8 percent and an evaluation period of 100 years. The Division Engineer recommends authorization of the Beaver Brook Dam and Reservoir project as set forth in his report, subject to certain conditions of local cooperation.

9. Public notice.--The Division Engineer issued a public notice stating his earlier recommendations and affording interested parties an opportunity to present additional information to the Board. No communications were received. Subsequently, his report was revised to require additional local cooperation which has been generally agreed to by local authorities.

Views and Recommendations of the Board of Engineers for Rivers and Harbors.

10. Views.--The Board of Engineers for Rivers and Harbors concurs in general in the views and recommendations of the Division Engineer. The proposed project is adequate for the planned purposes and is economically justified.

11. The Board notes that the major part of the flood damages prevented by the project would occur in the city of Keene, and are local in character; thus, the requirement of local cooperation specified by the Flood Control Act of 1936 for local protection projects should apply. The Board concludes that the proposed requirements of local cooperation are appropriate.

12. Recommendations.--Accordingly, the Board recommends the construction of a dam and reservoir on Beaver Brook, in the city of Keene, New Hampshire, for flood control, recreation, fish and wildlife conservation, and future water supply, generally in accordance with the plan of the Division Engineer, and with such modifications thereof as in the discretion of the Chief of Engineers may be advisable, at an estimated first cost of $1,377,000: Provided that prior to construction local interests furnish assurances satisfactory to the Secretary of the Army that they will:

a. In accordance with the Federal Water Project Recreation Act:

(1) Administer project land and water areas for recreation and fish and wildlife enhancement;

(2) Pay, contribute in kind, or repay (which may be through user fees) with interest, one-half of the separable cost of the project allocated to recreation and fish and wildlife enhancement, an amount currently estimated at $51,500, of which $48,000 is for general recreation and $3,500 for fish and wildlife enhancement;

(3) Bear all costs of operation, maintenance and replacement of lands and facilities for recreation and fish and wildlife enhancement, an amount currently estimated at $5,400 annually;

b. Repay all costs allocated to water supply, in accordance with the Water Supply Act of 1958, as amended, presently estimated at $314,000 for construction and $1,800 annually for operation, maintenance, and replacements;

c. Contribute 13.9 percent of the total project cost, representing the cost of lands, easements, rights-of-way, and relocations allocated to flood control, an amount presently estimated at $192,000, either in cash or in kind, and bear all costs of operation, maintenance, and replacements for flood control estimated at $3,700 annually: Provided that, if in cash, such contribution may be paid either in a lump sum prior to commencement of construction or in installments prior to commencement of pertinent items, in accordance with construction schedules as required by the Chief of Engineers, the final allocation of cost to be made after the actual costs have been determined;

d. Hold and save the United States free from damages due to the construction works;

e. Protect channels downstream from the reservoir from encroachment which would adversely affect reservoir operation;

f. Exercise to the full extent of their legal capability, control against removal of water in the watershed which will affect the reservoir's water supply storage and the development of dependable stream regulations; and

g. Obtain water rights needed for storage and use of water, resolve any conflicts in water rights necessary to assure effective operation of the project, and use water in a manner consistent with Federal and State laws.

13. The Board further recommends that, following authorization of the project, detailed site investigation and design be made for the purpose of accurately defining the project lands required; that subsequently, advance acquisition be made of such title to such lands as may be required to preserve the site against incompatible developments; and that the Chief of Engineers be authorized to participate in the construction or reconstruction of transportation and utility facilities in advance of project construction, as required to preserve such areas from encroachment and avoid increased costs for relocations.

14. The ultimate net cost to the United States after repayment of the non-Federal share of costs apportioned to flood control, recreation and fish and wildlife, and water supply is estimated at $819,500 for construction and $1,700 annually for operation, maintenance, and major replacements.

FOR THE BOARD:

R. G. MacDONNELL
Major General, USA
Chairman

CONNECTICUT RIVER FLOOD CONTROL

INTERIM REPORT

on

REVIEW OF SURVEY

BEAVER BROOK DAM AND RESERVOIR

BEAVER BROOK, ASHUELOT RIVER

CONNECTICUT RIVER BASIN

KEENE, NEW HAMPSHIRE

DEPARTMENT OF THE ARMY
New England Division, Corps of Engineers
Waltham, Mass.

July 1965

Revised December 1966

SYLLABUS

The Division Engineer finds that there is need for modification of the existing plan for flood control in the Connecticut River Basin, in order to insure the stability of present development, the security and health of the inhabitants, and the preservation and growth of existing economic values. He finds that Beaver Brook causes extensive damages along its watercourse into and through the city of Keene, New Hampshire. He concludes that flood control measures are necessary and warranted. He also finds need in the Beaver Brook watershed to provide storage for future municipal water supply and that, in view of local desires, the storage may be utilized in the interim period to satisfy immediate needs for the preservation and development of recreation including fish and wildlife resources.

The Division Engineer recommends that the authorized plan for flood control in the Connecticut River Basin be modified to provide for the construction of a multiple-purpose dam and reservoir on Beaver Brook in Keene, New Hampshire, providing storage for flood control, general recreation, fish and wildlife conservation, and future water supply, at an estimated total first cost of $1,377,000.

He further recommends that, prior to initiation of construction of the Beaver Brook Dam and Reservoir, non-Federal interests give assurances satisfactory to the Secretary of the Army that they will:

1. Provide without cost to the United States, all lands, easements, and rights-of-way necessary for the construction and operation of the project, currently estimated at $176,000;

2. Hold and save the United States free from damages due to the construction works;

3. Maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army;

4. Provide without cost to the United States all alterations, replacements and relocations of existing utilities and highways currently estimated at $226,000;

5. In accordance with the Federal Water Project Recreation Act, Public Law 89-72;

a. Administer project land and water areas for recreation and fish and wildlife enhancement;

b. Pay, contribute in kind, or repay (which may be through user fees) with interest, one-half of the separable cost of the project allocated to recreation and fish and wildlife enhancement, an amount currently estimated at $51,500;

c. Bear all costs of operation, maintenance and replacement of lands and facilities for recreation and fish and wildlife enhancement, an amount currently estimated at $7,100 on an average annual basis. Provided, that the sizing and responsibility for development, operation, maintenance, and replacement of the recreation and fish and wildlife enhancement features of the reservoir may be modified in accordance with the alternatives provided in the Water Project Recreation Act, depending upon the intentions of non-Federal interests regarding participation in the costs of these features at the time of reservoir construction and subsequent thereto, and that appropriate adjustments reflecting such modifications may be made in the allocation of costs to other project purposes.

6. Prior to construction of the water supply features, agree in accord with the Water Supply Act of 1958, as amended, to:

a. Reimburse the United States that portion of the construction costs allocated to future water supply, amounting to $104,000. This reimbursement shall be made within the life of the project, but in no event shall the repayment period exceed 50 years after the project is first used for water supply purposes, except that no payment need be made on this amount or interest charged thereon until storage is first used for water supply purposes, but in no event shall the interest-free period exceed 10 years;

b. Assume full responsibility and bear all costs of operation, maintenance and replacement of the project features presently included for future water supply. At such time as the reservoir is utilized for water supply, assume cost of operation, maintenance and replacement allocated to water supply.

7. Obtain water rights necessary for the use of stored water for water supply purposes and hold the Government harmless from liability for or on account of any claim for damages which may be made or asserted as the result of the storage and withdrawal of water by the user. Use of the water shall be in a manner consistent with Federal and State laws;

8. Protect Beaver Brook channels downstream from the dam from encroachments which would adversely affect reservoir operation; and,

9. Exercise to the full extent of their legal capability, control against removal of water in the watershed which will affect the reservoir's water supply storage and the development of dependable stream regulations.

The ultimate Federal first cost for the Beaver Brook multiple-purpose dam and reservoir, exclusive of pre-authorization costs, is currently estimated at $819,500; the non-Federal first cost is estimated at $557,500. The Federal appropriation requirement is presently estimated at $975,000 including reimbursable costs of $104,000 and $51,500 for water supply and recreation, respectively. Net average annual costs for operation, maintenance and major replacements which are items of local responsibility, are estimated at $12,600.

R 3/6/67

INTERIM REPORT ON REVIEW OF SURVEY
FOR FLOOD CONTROL

CONNECTICUT RIVER BASIN

BEAVER BROOK DAM AND RESERVOIR
BEAVER BROOK, ASHUELOT RIVER
KEENE, NEW HAMPSHIRE

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I	Public Hearing
II	Information Called for by Senate Resolution 148

DEPARTMENT OF THE ARMY
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Mass. 02154

NEDED-D

5 December 1966

SUBJECT: Interim Report on Review of Survey for Flood Control and Allied Purposes, Connecticut River Basin, Beaver Brook Dam and Reservoir, Keene, New Hampshire

TO: Chief of Engineers
ATTN: ENGCW-PD

SECTION I - AUTHORITY

1. AUTHORIZING RESOLUTION

This report is submitted pursuant to authority contained in Resolution by the Committee on Public Works of the United States Senate, adopted 3 October 1960, which reads in part as follows:

> "That the Board of Engineers for Rivers and Harbors, ...be, and is hereby, requested to review the reports of the Chief of Engineers on the Connecticut River Basin, Vermont, New Hampshire, Massachusetts and Connecticut, published as House Document Numbered 455, Seventy-fifth Congress, second session, with a view to determining whether the recommendations contained therein should be modified in any way at the present time, with particular reference to providing flood protection along Beaver Brook, a tributary of the Connecticut River at and in the vicinity of Keene, New Hampshire."

2. ASSIGNMENT OF STUDY

In letter dated October 3, 1960, the Chairman of the Committee on Public Works of the United States Senate, referred the foregoing Senate Resolution to the Chief of Engineers for appropriate action.

SECTION II - SCOPE

3. SCOPE OF REPORT

This interim report of survey scope comprises a review of the flood problems caused by Beaver Brook in Keene, New Hampshire as well

as its effect upon the downstream communities along the Ashuelot and Connecticut Rivers. Flood problems and solutions considered for the remainder of the Connecticut River Basin will be included in the comprehensive investigation now underway.

4. SCOPE OF STUDIES

a. Surveys and Studies. - U. S. Geological Survey maps, local maps and plane table topographic surveys of the project area were used in the study. Subsurface investigations consisted of field reconnaissance by geologists and soils engineers and subsurface explorations at the potential dam site by means of drive sample borings. Flood damage surveys consisted of field examinations of the project area and personal interviews with municipal officials, officers of industrial and commercial concerns, and private individuals experiencing losses. In addition, surveys of experienced flood damages on the Ashuelot and Connecticut Rivers made after the flood of September 1938, were reviewed. Office studies consisted of hydrologic and hydraulic analyses and estimates of quantities and costs of major items of construction, highway and utility relocations and real estate required for the project.

b. Consultations with Interested Parties. - A public hearing was held in Keene, New Hampshire, on 7 February 1962, at which time local interests requested that measures be taken to alleviate the flood problems in Keene resulting from flood flows in Beaver Brook. A digest of the public hearing is given in Attachment I of this report. On 21 April 1966, the Keene City Council adopted a resolution approving a multiple-purpose dam and reservoir on Beaver Brook in Keene, New Hampshire to include flood control, recreational features and future water supply. Several meetings have been held with other interested Federal agencies, State and local officials, and with private individuals.

c. Field Reconnaissance. Field reconnaissance of the problem area has been made by the Division Engineer and his representatives.

SECTION III - PRIOR REPORTS

5. PRIOR REPORTS

There are no prior reports concerning flood control measures on Beaver Brook in Keene, New Hampshire. Flood control in the Connecticut River Basin has been considered in the reports noted in the following paragraphs.

6. PUBLISHED REPORTS

a. "308" Report. - A report dated 28 February 1935 and printed as House Document No. 412, 74th Congress, 2nd Session, considered the

needs for navigation, water power and flood control on the Connecticut River and its tributaries. The report recommended an initial plan for flood control consisting of 10 reservoirs located in New Hampshire and Vermont. The plan was authorized by Public No. 738, 74th Congress, approved June 22, 1936, as amended by Public No. 111, 75th Congress, approved May 25, 1937.

b. 1937 Report. - A survey report dated 20 March 1937 and printed as House Document No. 455, 75th Congress, 2nd Session, reviewed previous reports on flood control for the Connecticut River Basin. The report proposed a revised comprehensive plan for flood control consisting of 20 reservoirs including Surry Mountain, and dikes at 7 localities. The report recommended that the authorization for additional reservoirs be deferred and that the authorized project be modified to provide for the protection of 7 cities by dikes and related works.

c. NENYIAC Report. - Flood control and allied water uses were also considered in Part 2, Chapter XXI, "Connecticut River Basin," of The Resources of the New England-New York Region. This comprehensive report inventoried the resources of the New England-New York area and contained a master plan to be used as a guide for the regional planning, development, conservation and use of land, water and related resources of the region. Prepared by the New England and New York Inter-Agency Committee, the report was submitted to the President of the United States by the Secretary of the Army on 27 April 1956, Part 1 and Chapter I of Part 2 are printed as Senate Document No. 14, 85th Congress, 1st Session.

7. OTHER STUDIES UNDERWAY

A comprehensive investigation of the water and related land resources of the Connecticut River Basin is presently underway. This study, when completed, will fulfill completely the requirements of the authorizing resolution for the subject study.

SECTION IV - DESCRIPTION

8. LOCATION AND EXTENT

The City of Keene is situated on the Ashuelot River, a tributary of the Connecticut River, and is located in Cheshire County in the southwestern part of New Hampshire, about 14 miles north of the Massachusetts border. The City comprises 37 square miles of land area located about 85 miles northwest of Boston, Massachusetts, and 54 miles southwest of Concord, New Hampshire. The Beaver Brook watershed is located in the City of Keene and in the townships of Gilsum and Sullivan. The watershed area of 10 square miles is rectangular in shape with a length of about 7 miles and a width of about 1-1/2 miles. The Beaver Brook dam site is on Beaver Brook approximately 2.5 miles north of the center of

Keene and about 1,100 feet upstream from the intersection of New Hampshire State Highway Route 9 and Beaver Brook. Six square miles of the watershed drainage area lie upstream from the dam site. Plate No. 1 shows the relative location of the project dam and reservoir.

9. TOPOGRAPHY

The topography of the Beaver Brook watershed area is characterized by rounded hills and relatively steep-sided valleys. From the New Hampshire State Highway Route 9 crossing of the brook southward to Keene, the stream descends fairly rapidly through a narrow part of the valley where it leaves the uplands and flows through the lowlands of Keene into a flat plain and joins The Branch. Above the Route 9 crossing, the valley widens somewhat and becomes open, containing a small pond and flat marshy areas. The hillsides are second growth woodland and brush. Elevations range from 773 feet above mean sea level, at the project dam site, to about 1,570 feet on the top of Spaulding Hill in the northeast corner of the watershed, a difference of about 800 feet. The area is sparsely settled.

10. GEOLOGY

The valley of Beaver Brook is physiographically located within the New England Upland in a maturely dissected region of moderately high relief. Glacial till generally blankets the bedrock surface and the area has been molded into low hill features known as drumlins. The till in the lower sides of the valley of Beaver Brook is overlain by remnants of gravelly terraces. The bedrocks of the region are principally Devonian in age and largely consist of granite and gneiss. Mica schist of the Littleton Formation narrowly fingers between these rocks along the valley of Beaver Brook.

11. STREAM CHARACTERISTICS

a. Ashuelot River. - The Ashuelot River in the Connecticut River Basin drains an area of 421 square miles at its confluence with the Connecticut River near Hinsdale, New Hampshire. Generally, the watershed is hilly with low mountains in the headwaters and a few natural lakes and ponds are also found in the area. The river has a total fall of 1,475 feet in its length of 64 miles, but much of this drop is concentrated near the headwaters. The two main tributaries of the Ashuelot River are The Branch and the South Branch. The Branch, entering the Ashuelot River just below Keene, about 26.5 miles upstream from the mouth, is formed by the confluence of Minnewawa Brook and Otter Brook. The South Branch joins the Ashuelot River just above Swanzey Station, about 23.5 miles upstream from the mouth. The Ashuelot River and its two main tributaries and Beaver Brook converge in a flood plain just below the City of Keene. The portion of the Ashuelot River between the Faulkner and Colony Company Dam in Keene and the Dickinson Dam in West Swanzey is referred to as the Keene Flood Plain.

b. Beaver Brook. Beaver Brook, with a total drainage area of 10 square miles, is a tributary of the Ashuelot River in the Connecticut River Basin. The brook flows southward into and through the City of Keene falling rapidly to the flood plain where it joins the Branch within 500 feet of its confluence with the Ashuelot River. The brook has basically a single stream pattern with short side tributaries flowing from Bingham Hill State Forest and the eastern slopes of Webster Hill in the township of Gilsum, and from the southwestern slopes of Spaulding Hill in the townships of Sullivan and Gilsum. Although Beaver Brook falls nearly 1,000 feet in a distance of about 8 miles, the lower 2 miles and the portion in the vicinity of the proposed reservoir are relatively flat. Immediately downstream from the dam site, the channel is fairly steep until it reaches the flood plain.

12. AREA MAPS

The Ashuelot River and its watershed including Beaver Brook is shown on standard quadrangle sheets of the U. S. Geological Survey Maps to a scale of 1:62,500 with 20-foot contour intervals. A map of the upper part of the Beaver Brook watershed is shown on Plate No. 1.

SECTION V - ECONOMIC DEVELOPMENT

13. POPULATION

The City of Keene and the 15 towns within the Ashuelot River Watershed experienced a population growth of 11% between 1940 (25,300) and 1950 (28,200), and another 11% between 1950 and 1960 (31,500). The City of Keene, comprising 50% of the population in the watershed, and the adjoining town of Swanzey, comprising 10% of the population, have experienced 80% of this growth. Keene was first settled in 1736, although it was abandoned for a time in 1747 because of Indian raids. The town charter was granted in 1753. The City of Keene was established by the New Hampshire legislature in 1865, and the charter officially adopted by the community in 1874. The population, estimated at 18,000 in 1962, is expected to reach 20,000 by 1970. Property valuation is presently assessed at $63,000,000. Keene is the market center of a large area with important farming activities and with an expanding and diversified industrial capacity. Founded in 1909, and located in the city, is Keene Teachers College with an enrollment of 700 students.

14. TRANSPORTATION

The Keene area is served by a network of highways. Within its 37 square miles, it has more than 100 miles of streets and roads.

The three principal routes are State Highways No. 9, 10 and 12. The main line of the Boston and Maine Railroad and seven trucking lines with four major terminals in Keene provide freight service. Three bus lines and a commercial airport provide passenger service to the city.

15. MANUFACTURING

In a recent study of economic development in sub-state areas of the New England States, the counties of Cheshire and Sullivan were found to have a higher proportion of total employment engaged in manufacturing activity than other New Hampshire subareas. Keene's growing industrial facilities employ 7,300 people and include some 40 industries of broadly diversified types. These include furniture, optical goods, shoes, printing, textiles, chemicals, food products, precision instruments and machine tools. The Keene Regional Industrial Foundation, set up by city businessmen within the last decade, has played an important part in the city's industrial growth. New industries have moved into the area and existing establishments have increased their facilities.

Considerable industrial activity is also found downstream from Keene on the Ashuelot River in the communities of Swanzey, Winchester and Hinsdale. Twenty-one firms are located within the 3 communities and over 1300 people are employed by these establishments. Manufactured items include furniture, screw machine parts, textiles (woolen), leather goods, trailers, wood products, tissue and paper commodities.

16. NATURAL RESOURCES.

Mineral resources of the Keene area include feldspar, beryl, mica, granite, sand and gravel. Second growth lumber is available, both hard and soft woods.

17. WATER SUPPLY

The existing water supply system for the City of Keene is municipally owned and is capable of supplying 5.9 mgd with 2.9 mgd supplied from Babbidge Reservoir augmented by Woodward Pond and 3.0 mgd from a well field in West Keene. Plans are currently underway to add an additional well to the system increasing their present water supply to at least 7.0 mgd. With an increasing population and continuing industrial expansion, Keene is fast approaching the point where demand will exceed the minimum yield of a dry year. Keene is founded on the site of a lake bed so that much of it is underlain by lake-bottom silt unsuitable for any major ground well system.

18. RECREATION

a. General. - Keene is located in the Monadnock Region of New Hampshire, an area known for scenic beauty and tourism. Many tourists and vacationers visit the area annually for both summer and winter sports with Keene serving as a shopping center for the visiting population. Recreation areas, natural and developed, constitute an important resource to the City of Keene. Existing recreation areas are heavily used and facilities are inadequate to meet present and future demands.

b. Fish and Wildlife. - The lands and waters of Beaver Brook support moderate quality fish and wildlife resources which are predominantly associated with a 25-acre wetland within the lower reaches of the proposed reservoir. Beaver Brook, upstream from the project area, has been occasionally stocked with trout. The principal fish species are chain pickerel and brown bullhead. The 25-acre wetland, most of which is the bed of an old shallow mill pond, maintains a small breeding population of wood and black ducks which generate the major hunting interest. Grouse, woodcock, hare, and deer utilize the project area and contribute to the diversity of hunting opportunity. Fur animals such as muskrat, mink, otter, and beaver, though present, constitute a resource of minor value.

SECTION VI - WEATHER AND FLOODS

19. CLIMATOLOGY

The Ashuelot River watershed has a variable climate, characterized by frequent but generally short periods of heavy precipitation. Winters are moderately severe, with sub-zero temperatures rather common and summers are warm with extreme highs close to 100° F. The mean annual precipitation at Keene is 38.7 inches. The greatest annual precipitation recorded was 51.2 inches in 1951, and the least annual amount was 27.1 inches, recorded in 1894. The average annual snowfall for 66 years of record is 62.3 inches. Generally, the snow cover is at a maximum about the middle of March.

20. STREAMFLOW

The U. S. Geological Survey has published records of river stages and streamflows at five locations in the Ashuelot River watershed for various periods from 1907 through 1963. There is no published record of streamflow on Beaver Brook. However, a temporary recording gage has been in operation on Beaver Brook since October 1962. This gage records the runoff from a drainage area of 8.25 square miles.

21. RUNOFF

Runoff records for neighboring Otter Brook are considered the most representative for flows on Beaver Brook. The annual runoff for 40 years of record through September 1963 at the Otter Brook gage varied from 12.63 inches to 32.93 inches, with a mean of 22.54 inches. The mean annual runoff represents about 60 percent of mean annual precipitation.

22. FLOODS OF RECORD

a. General. - Outstanding floods on the Ashuelot River result from early spring storms combined with melting snow, such as the flood of March 1936, or from summer or fall storms, such as the record flood of September 1938. In addition, local thunderstorms can cause flash floods on the tributaries.

b. Flood History. The Ashuelot River watershed has experienced seven major floods in recent years. Pertinent data on these floods are given in Table B-8 of Appendix B. The largest flood of record occurred in September 1938 when a hurricane passed over the watershed. Rainfall accompanying this storm, combined with precipitation of the previous three days, totaled more than 10 inches. The most recent flood of April 1960 occurred when 3 to 4 inches of rain fell on snow with a high water content. A review of the record of the City of Keene reveals that flooding on Beaver Brook has been a recurring problem since the earliest times. Periodically, at five to ten-year intervals since 1813, the brook has flooded extensive areas in Keene.

23. FLOOD CHARACTERISTICS

The more critical floods in the area develop from rainfall alone, where the intensity of the rainfall rather than the volume may determine the magnitude of the peak flows. The quick development of floods is due to the short, steep tributaries and hillside slopes which empty into the main channel almost concurrently. In the lower reaches of Beaver Brook in Keene, water surface elevations have been affected by flood stages in the Ashuelot River and by constrictions in the brook channel, as well as by total runoff within the drainage area. With a high degree of control of the Ashuelot River provided by Surry Mountain and Otter Brook Dams, flood stages in the Ashuelot River will be less critical than in the past. The problems of channel capacity in Beaver Brook, however, have continued to affect water levels and drainage to Keene, and it is anticipated that another major storm in the watershed, without flood control on the brook itself, would cause extensive flooding to industrial, commercial and residential areas of the City.

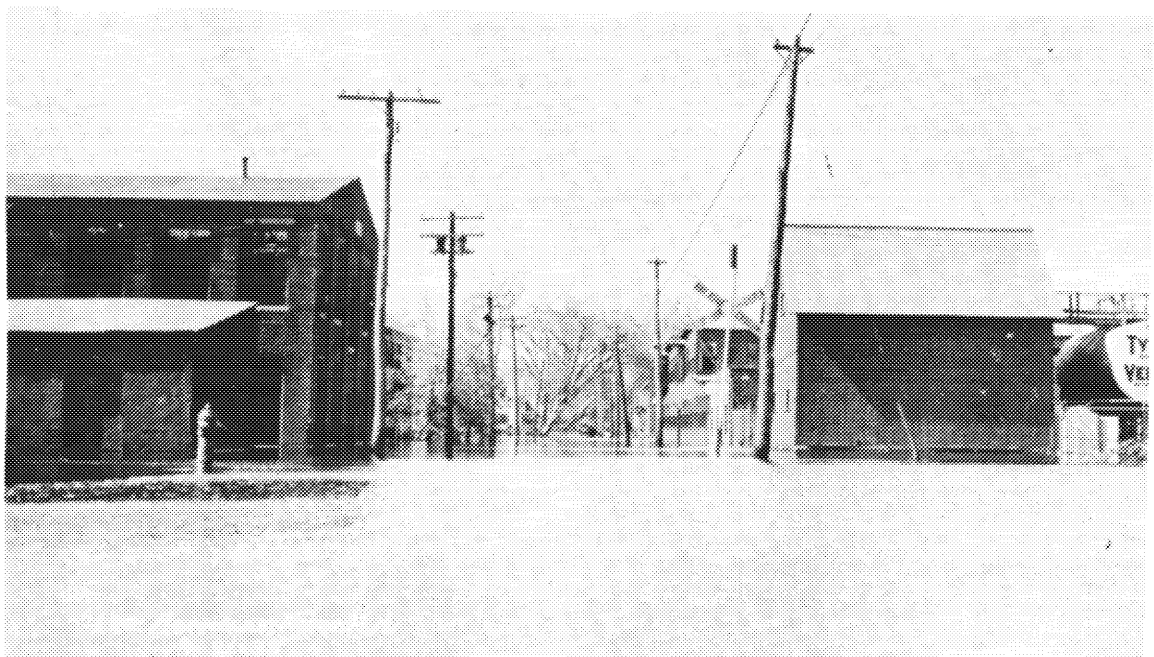
SEPTEMBER 1938 FLOOD-ON BEAVER BROOK

Flood scene along ℄ Beaver Brook
between Beaver and Roxbury Streets

Beaver Brook at Main Street

SEPTEMBER 1938 FLOOD-ON BEAVER BROOK

Church Street - from Valley Street -
Looking west.



Water Street - looking west

24. STANDARD PROJECT FLOOD

A standard project flood on Beaver Brook was developed to test the effectiveness of the proposed reservoir, and as a basis for the design of alternative methods of flood control. It was derived by using a standard project storm and the unit hydrograph developed from an analysis of floods of record. The peak inflow, as developed, is 4,500 cubic feet per second, equivalent to 750 cubic feet per second per square mile of drainage area.

25. MAXIMUM PROBABLE FLOOD

The spillway design flood inflow for Beaver Brook Reservoir was developed from the probable maximum precipitation and the adopted unit hydrograph. The peak inflow, as developed, is 10,000 c.f.s., equivalent to about 1,670 csm.

SECTION VII - EXTENT AND CHARACTER OF FLOODED AREA

26. GENERAL

The Ashuelot River has caused heavy flood losses since the first development of its flood plains. The flat basin in which it lies was the bed of an ancient lake of the glacial area. The Ashuelot River flowing through the basin is joined just below Keene by several small tributaries, including Beaver Brook and Otter Brook, and by the South Branch further downstream. This area forms a flood plain, with poor natural drainage. In the major floods of 1936 and 1938, overflow and backup of these streams flooded large areas, causing substantial losses to industrial, residential and business properties. The operation of Surry Mountain Dam on the Ashuelot and Otter Brook Dam on Otter Brook have substantially reduced flood stages on the Ashuelot, and the authorized Honey Hill Dam on the South Branch, if built, would furnish additional control. Still vulnerable, however, is the thickly settled area along the banks of Beaver Brook in Keene and the low-lying residential and commercial areas in Swanzey, Winchester and Hinsdale on the Ashuelot River.

27. FLOOD PLAIN

Of the 63 industrial firms in the Ashuelot River Basin, 27 are located in the flood plain. Of these, 20 plants are located in the Beaver Brook area and employ 1,560 persons with an annual payroll of $6,750,000. In the more recent flood of April 1960, some 60 acres of the Beaver Brook flood plain were inundated to varying depths. Residential areas east of the business district were cut off from

access by wheeled vehicles, and boats were used in the streets. Storm and sanitary sewers backed up, causing nuisance flooding in streets and yards above the high water level. The April 1960 flood resulted in the formation of the Beaver Brook Association, which petitioned the City Council for flood relief. A flood in October 1959 of the same peak flow as April 1960 caused nuisance damage only because of lesser volume and shorter duration.

Downstream of Keene, the April 1960 flood caused only nuisance flooding but flood stages of the magnitude of September 1938 or March 1936 would cause losses at 6 manufacturing plants employing approximately 1,000 people and would also affect numerous residential properties in Swanzey, Winchester and Hinsdale and some commercial development in Winchester.

SECTION VIII - FLOOD DAMAGES

28. EXPERIENCED LOSSES

a. Flood of September 1938. - The record flood of September 1938 caused damages in the Ashuelot River Basin amounting to $1,138,000. The heaviest losses occurred in the densely-populated areas along the banks of the Ashuelot River and Beaver Brook. Some 372 properties, including 347 homes, 15 commercial firms and 10 industrial plants, experienced losses along Beaver Brook amounting to $218,000.

b. Flood of April 1960. - The flood of April 1960 caused damages estimated at $100,000 in Keene. Eleven industrial firms, seven commercial establishments and about 250 residences housing approximately 400 families were affected by flooding of grounds and cellars. The estimated damages do not include municipal costs such as cleaning up debris in the flooded area, or providing emergency facilities.

29. RECURRING LOSSES

Under conditions existing in 1965 without flood protection, it is estimated that a recurrence of 1938 flood stages in the Ashuelct River Basin would cause losses amounting to $5,450,000. Nearly $3,845,000 of this amount would be experienced in the City of Keene and would be distributed as follows: $3,120,000 along Beaver Brook and the remainder on the Ashuelot River. Even with the operation of the existing projects at Surry Mountain and Otter Brook, losses

APRIL 1960 FLOOD-ON BEAVER BROOK

Church Street at Guernsey Street,
Looking East
(Note boat at right of picture)

Beaver Street, looking south

amounting to $1,875,000 would be experienced within the zone influenced by Beaver Brook. Adding the authorized Honey Hill Dam to the system would reduce this loss to $1,255,000. Tables A-II and A-III in Appendix A show recurring and preventable losses by existing, authorized and recommended projects.

30. AVERAGE ANNUAL LOSSES

Estimated recurring losses were converted to average annual losses as a basis for determining average annual benefits for use in economic evaluation. The average annual loss in the Ashuelot River Basin in the reaches below Beaver Brook Dam is $462,300 without flood protection. Of this loss, $205,600 occurs on Beaver Brook and the remainder on the Ashuelot River below Surry Mountain in Keene. Operation of the existing Surry Mountain and Otter Brook Dams will reduce annual losses on Beaver Brook to $93,800 and losses on the Ashuelot River zones to $51,000, resulting in a total annual loss of $144,800 under present conditions. The estimate of annual losses has been derived in accordance with Corps of Engineers' practice of correlating stage-damage, stage-discharge, discharge-frequency, and damage-frequency relationships. Appendix A contains detailed descriptions of damage surveys, loss summaries, and annual losses and benefits.

31. TRENDS OF DEVELOPMENT

Keene, New Hampshire has shown a steady economic growth for the past 30 years. Trends, established by review of statistics such as value of manufacture added, retail sales, and population, and availability of land within the flood plain, indicate that flood losses will grow at the rate of 1.5 percent per year for the next 20 years, before available lands are fully utilized. On an equivalent basis, annual benefits for growth over the life of the project would amount to $17,700 ($14,400 in the alternate system). Since project construction is not expected to materially hasten this growth, no enhancement benefits have been evaluated. Data on economic trends in Keene are set forth in Appendix A.

SECTION IX - EXISTING AND AUTHORIZED CORPS OF ENGINEERS' FLOOD CONTROL PROJECTS

32. GENERAL

There are no existing Corps of Engineers' flood control projects in the Beaver Brook watershed. Completed and recommended

flood control projects in the Ashuelot River Basin which affect flood stages in the downstream portion of the basin are discussed below.

33. COMPLETED PROJECTS

a. Surry Mountain Dam and Reservoir. - Surry Mountain Dam, authorized by the Flood Control Act, approved 28 June 1938 (Public Law 761, 75th Congress), is located on the Ashuelot River in the Town of Surry, about 5 miles north of Keene, New Hampshire. The reservoir has a flood control storage capacity of 31,300 acre-feet, and recreation storage capacity of 1,300 acre-feet totaling 32,600 acre-feet, equivalent to 6.1 inches of runoff from the 100 square mile drainage area. Construction of the dam was initiated in August 1939 and completed in June 1942. The estimated cost of new work for the project is $2,225,900 for construction and $324,100 for lands and damages, a total of $2,550,000. Total costs of the project to 30 June 1964 are $2,380,450 for new work and $444,246 for maintenance. The average annual maintenance cost for the 5 years ending 30 June 1964 was $30,925. The project is complete except for construction of additional recreation facilities.

b. Otter Brook Dam and Reservoir. Otter Brook Dam, authorized by the Flood Control Act, approved 3 September 1954 (Public Law 52, 83rd Congress), is located on Otter Brook on the boundary between the City of Keene and the town of Roxbury, New Hampshire. The dam is approximately 2.2 miles east of the center of Keene. The reservoir has flood control storage capacity of 17,600 acre-feet, and recreation storage capacity of 700 acre-feet totaling 18,300 acre-feet, equivalent to 7.3 inches of runoff from its drainage area of 47 square miles. Construction of dam and appurtenant works was initiated in September 1956 and completed in August 1958. The cost estimate for new work is $2,751,600 for construction and $1,378,400 for lands and damages, including highway relocation, a total of $4,130,000. Total costs of the project to 30 June 1964 are $4,050,662 for new work and $218,550 for maintenance. The average annual maintenance cost for the 5 years ending 30 June 1964 was $39,886. The project is complete except for construction of additional recreation facilities.

c. Flood Protective Works, Ashuelot River Below Keene, N. H. - Snagging and clearing work on the Ashuelot River from the railroad bridge in Keene to the covered bridge at Swanzey Station (22,800 feet) was authorized by the Chief of Engineers on 20 August 1953 in accordance with Section 13 of the Flood Control Act of 1946

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SECTION XI - IMPROVEMENTS DESIRED

37. FLOOD CONTROL

In order to ascertain the views of those interested in flood control and allied measures on Beaver Brook, a public hearing was held in Keene, New Hampshire, on 7 February 1962. Since the public hearing, several meetings sponsored and conducted by the City of Keene were held with local interests regarding the Beaver Brook Dam and Reservoir Project.

38. KEENE HEARING

The Keene public hearing was attended by about 250 persons including representatives of Federal, State and Municipal Governments, industrial and commercial interests, civic organizations and individuals concerned. Local interests expressed their interest in a flood control dam on Beaver Brook and emphasized the need for flood protection by citing damages, inconveniences and health hazards from flooding, as well as emergency costs and depreciation of property values. No opposition to the dam and reservoir plan was indicated. Testimony and remarks were predominantly in favor of flood control improvements in the Beaver Brook watershed. A digest of statements and letters submitted at the hearing is given in Attachment I.

39. RECREATION

A meeting was held in Keene, New Hampshire on 22 March 1965, attended by State and local officials and local news media. The purpose of the meeting was to introduce and outline to local interests the then proposed Water Projects Recreation Act, Public Law 89-72. By letter dated 24 March 1965, the City Manager of Keene expressed the desire of local interests to plan for construction of a multiple-purpose project to include flood control and a permanent pool for recreation which could also be utilized as a source of future water supply.

On 7 April 1965, a meeting was held at Keene, New Hampshire to obtain the views of interested parties with respect to the multiple-purpose dam and reservoir on Beaver Brook. Approximately 40 persons were in attendance, including State and local officials, Councilmen of the City of Keene, members of the Beaver Brook Association, local news media and other interested parties. On 15 April 1965, the City Council adopted a Resolution approving a multiple-purpose flood control dam and reservoir on Beaver Brook including recreational features. More recently, City Officials have confirmed this decision by approving a subsequent resolution dated 21 April 1966.

40. WATER SUPPLY

In a letter dated 20 March 1962, the City Manager of Keene requested that a study be made of the possibility of including water supply storage in the proposed Beaver Brook flood control reservoir. Studies of the water supply needs and potential services of water for the City of Keene, prepared by private engineering consultants and reported upon by the U. S. Public Health Service (now the Federal Water Pollution Control Administration) in 1962 indicated that the demand for water will increase on the average from about 3.5 mgd to 6 mgd within the next 50 years. In their 1966 report the Federal Water Pollution Control Administration indicated that the water supply demand will average 7.1 mgd in the year 2010 with maximum daily consumption approaching 11 mgd. Development of an additional source of supply with a safe yield of 4.0 mgd (equivalent to 3,000 acre-feet storage at damsite) appears highly desirable. After considering the effect on the City's finances and water rates, the City Council adopted a Resolution on 21 February 1963, to approve the construction of a flood control dam on Beaver Brook with minimum provisions for future water supply consisting of a water supply conduit with gate valve controls. More recently, on 21 April 1966, City officials adopted a Resolution approving the construction of a multiple-purpose flood control dam and reservoir on Beaver Brook, including recreational features and future water supply.

SECTION XII - FLOOD PROBLEMS, RELATED PROBLEMS, AND SOLUTIONS CONSIDERED

41. FLOOD PROBLEMS

The City of Keene is susceptible to floods caused by rain, melting snow, and a combination of both. The Ashuelot River, which flows through the flood plain of Keene, is joined by a number of smaller streams including Beaver Brook. The sluggish characteristics of the Ashuelot River produced by its low stream gradient and flat topography, provides natural storage for floodwaters causing backwater conditions. In the lower reaches of Beaver Brook, water surface elevations are adversely affected by flood stages in the Ashuelot River, by constrictions in the brook channel, and by total runoff within the drainage area. Although Surry Mountain flood control dam on the Ashuelot River, and Otter Brook flood control dam on Otter Brook, a tributary of the Ashuelot River, control the flood discharges from about one-half the area that drains into the flood plain of Keene, high runoff from Beaver Brook continues to raise water levels causing overbank flows. On such occasions, industrial and commercial establishments suffer heavy losses, cellars and streets in populated residential areas are flooded, storm drains become almost completely inoperative and health hazards result from backup of the sanitary sewers. In past

floods, raw sewage has been discharged into the streets when the covers were forced off manholes. The city's one producing water supply well has also been flooded, and high municipal costs resulted from cleanup operations.

42. SOLUTIONS CONSIDERED

Alternative methods of solving the flood problems were considered including local protection measures and channel inprovements, diversion and relocation of Beaver Brook, modification of the dam at West Swanzey on the Ashuelot River, channel improvement of the Ashuelot River, flood plain zoning, and evacuation and resettlement. Local protection measures and channel improvements on Beaver Brook were found to be impracticable due to the extensive construction costs involved through the developed area of the city. Diversion and relocation of the brook were found to entail inordinately high construction costs. Modification of the dam at West Swanzey would have little effect on flood stages in the Keene flood plain. Channel improvement of the Ashuelot River was found to be enormously expensive. Evacuation of the flood plain was also rejected as impracticable due to the high value of improved real estate and municipal improvements. Flood plain zoning is possible in limited areas, but impracticable in the intensely occupied areas of Keene. These alternative methods are described further in Appendix C. Construction of a flood control dam and reservoir on Beaver Brook was found to provide the most practical means of alleviating the flood problems.

43. RELATED WATER RESOURCE DEVELOPMENTS

a. General. - In the development of plans for a flood control dam and reservoir on Beaver Brook, consideration was given to other related water resource improvements that may be affected by or coordinated with the proposed works, such as hydroelectric power development, water supply, abatement of stream pollution and provision of permanent pools in the reservoir for fish and wildlife conservation and for recreation.

b. Hydroelectric Power. - In view of the small drainage area controlled and the absence of dependable flow and head, hydroelectric power development would be impracticable.

c. Water Supply. - Studies by the Federal Water Pollution Control Administration (FWPCA) of water supply needs and potential sources for Keene indicate that, by the year 2010, the average demand will reach 7.1 mgd (million gallons per day), with maximum daily consumption approaching 11.0 mgd. In 1965, the city's daily water use averaged 3.2 mgd with maximum daily consumptions of over 5 mgd. The FWPCA, in their letter dated 23 June 1966, point out that while the safe yield of the existing Keene system is 5.9 mgd, an additional

future source of supply with a safe yield of at least 4.0 mgd is highly desirable. An additional well is currently being planned by the City of Keene which would increase the safe yield of their existing system to at least 7.0 mgd. City officials recognize a need for a future source of water supply and concur that provisions for water supply storage in the multiple-purpose reservoir project is of substantial benefit to the City of Keene.

d. Streamflow Regulation for Quality Control. - The U. S. Department of Health, Education and Welfare has considered the need for low-flow augmentation for water quality control in Beaver Brook. No water quality problems are anticipated between the site of the proposed reservoir and the confluence of Beaver Brook and Ashuelot River by agencies of the State of New Hampshire. Furthermore, the contributory flows from the Beaver Brook watershed amount to less than 3 percent of the flow in the Ashuelot River and are of limited significance relative to quality control along the Ashuelot and the Connecticut Rivers.

e. Fish and Wildlife Development. - The U. S. Fish and Wildlife Service has indicated interest in the development of fish and wildlife conservation within the proposed project. The construction of the Beaver Brook Dam will create a 203-acre reservoir with suitable habitat for predominantly warm-water fish species. Reservoir fishery resources will consist primarily of chain pickerel, brown bullhead, large mouth bass, and other sunfishes. Downstream from the dam, conditions will not be sufficiently altered to create a significant fishery. The 203-acre reservoir, although beneficial to fisheries, will permanently inundate a 25-acre wetland area currently productive to water fowl. An opportunity exists in the headwaters of the reservoir to mitigate wildlife losses with a 50-acre pool which can be created by construction of a water control structure. Further details are contained in Appendix E.

f. Recreation. - With the continued trend to greater leisure time available to participate in outdoor recreation, greater pressures are being brought upon existing public facilities throughout New England. The construction of the Beaver Brook Dam and Reservoir provides an excellent opportunity for the development of a permanent recreation pool and facilities. The matter is discussed in detail in Appendix E.

SECTION XIII - PLAN OF IMPROVEMENT

44. GENERAL

Consideration was given to including the water resource needs for the Keene area insofar as possible through full development of the Beaver Brook site. In this connection, the considered multiple-purpose dam and reservoir on Beaver Brook would include flood control,

a permanent pool for recreational purposes, fish and wildlife conservation, and future water supply. The principal features of construction will consist of a dam and reservoir, a concrete chute-type spillway, gated but uncontrolled outlet works, relocation of State Highway Route 10, water supply conduit and gate valves for future use, and a water control structure in the upper reaches of the reservoir. The site selected for the construction of the dam is geologically and topographically suited for the proposed structures. General plans of the dam and appurtenant structures are shown on Plate No. 2. A brief description of the project follows with pertinent data summarized in Table 1.

45. BEAVER BROOK DAM AND RESERVOIR

The dam, at full flood control pool elevation 822 feet, mean sea level datum, will create a reservoir about 2.5 miles long with a surface area of approximately 310 acres, impounding a capacity of 5,750 acre-feet. A permanent pool for recreation and future water supply maintained by the controlled outlet works at elevation 811 feet, mean sea level datum, will have a surface area of approximately 203 acres and a storage capacity of 3,000 acre-feet equivalent to 9.4 inches of runoff. The flood control storage provided is 2,750 acre-feet equivalent to 8.6 inches of runoff from the total drainage area of 6 square miles. The limits of the reservoir as well as the drainage area are shown on Plate No. 1. The dam will be constructed of compacted earth fills with rock slope protection on upstream and downstream slopes and will be approximately 950 feet long, 60 feet high at the stream bed, with a top elevation of 833 feet, mean sea level datum. The top of dam will be 20 feet wide and will provide for an access road to the spillway. A chute-type spillway with a concrete ogee weir 100 feet long at crest elevation of 822, capable of passing a peak discharge of 6,000 cubic feet per second with a surcharge of 6.3 feet and 4.7 feet of freeboard between maximum water level and the top of dam, will be constructed on rock in the west abutment of the dam. The outlet works will consist of a cast-in-place rectangular concrete conduit 5 feet wide by 5 feet high, with gate control at the intake structure. A gated 24-inch pipe with a box inlet will be provided as a low flow outlet and will also serve as a draw-down inlet when necessary. A gated overflow weir with stoplogs will be provided to maintain the permanent pool at elevation 811 feet, mean sea level. Flood discharges will be automatic with no gate control. Details and section of the dam are shown on Plate No. 2.

Construction of the project will require the relocation of about 2.6 miles of Route 10 presently located in the reservoir area. The final alignment of Route 10 will be determined through agreement with the State of New Hampshire. Utilities, consisting of telephone and electric power lines along Route 10 and Sullivan Road will also be

relocated. In addition, a 115 KV transmission line which crosses the reservoir area about 1,200 feet upstream of the dam will be relocated south of the dam site. The approximate location of the relocated highway is shown on Plate No. 1. Provisions for future water supply will consist of the construction of two intake pipelines, two gate valve controls, and a 24" pipeline in the box conduit outlet which will be plugged until such time as the water is needed by the City of Keene.

The upstream water control structure will create a pool with a surface area of approximately 50 acres at elevation 826 feet, mean sea level, impounding a capacity of about 175 acre-feet. The pool will be maintained by an overflow box inlet structure and a 36-inch bituminous coated corrugated metal pipe outlet which will handle normal flows. The structure will be constructed of rolled earth fill with a grassed top and slopes and would be approximately 430 feet long, 11 feet high at the stream bed, and a top width of 20 feet at elevation 828 feet, mean sea level datum. An 80-foot grass spillway at elevation 826.5 feet mean sea level will be located along the left bank of the structure to handle flood flows.

46. REAL ESTATE REQUIREMENTS

The land and improvements to be acquired in fee for all water resource project purposes is estimated at 730 acres. It consists of an area bounded by the flood control pool at maximum surcharge elevation 828 mean sea level and also includes those areas required for the construction of the dam, appurtenant structures, work and borrow areas, and the relocation of Route 10. Details and estimates of real estate costs are included in Appendix D.

TABLE NO. 1

PERTINENT DATA

BEAVER BROOK DAM AND RESERVOIR

Drainage Area	6 square miles
Dam	
Type	Rolled earth fill with rock slope protection
Top elevation	833 feet, m.s.l.
Top width	20 feet
Maximum height	60 feet
Length	950 feet
Upstream slope	1 vertical on 3 horizontal
Downstream slope	1 vertical on 2.5 horizontal
Spillway	
Type	Concrete ogee weir
Peak design flood inflow	10,000 c.f.s.
Peak design flood outflow	6,000 c.f.s.
Crest elevation	822 feet, m.s.l.
Crest length	100 feet
Surcharge	6.3 feet
Freeboard	4.7 feet
Outlet Works & Intake Structure	
Outlet conduit	Gated 5'x5' concrete box
Intake structure	15'x15'x45' high concrete structure with overflow weir

Low flow outlet	24" R.C. pipe
Water supply line	24" R.C. pipe (two level intake)
Sluice gates	5'x5' and 2'x2'
Water supply gate valves	2-24"

Storage Capacities

Recreation and water supply	3,000 acre-feet
Flood control	2,750 acre-feet
Total	5,750 acre-feet

Water Surface Elevations and Areas

Recreation and water supply pool	Elev. 811 - 203 acres
Flood control	Elev. 822 - 310 acres
Maximum surcharge	Elev. 828.3 - 410 acres

Stream Flow at Dam Site

Maximum recorded discharge	1800 c.f.s.
Average discharge	9 c.f.s.
Storm of April 1960	400 c.f.s.
Storm of September 1938	1800 c.f.s.

Upstream Water Control Structure

Type	Rolled earth fill with grassed top and slopes
Top elevation	828 feet, m.s.l.
Water surface elevation and area	826 feet, m.s.l. - 50 acres
Top width	20 feet

Maximum height	11 feet
Length	430 feet
Upstream slope	1 vertical on 3 horizontal
Downstream slope	1 vertical on 2.5 horizontal
Storage capacity	175 acre-feet
Overflow and outlet works	Overflow box inlet structure and 36-inch BCCM pipe
Grass spillway	80 feet, 826.5 feet, m.s.l.

Construction Period

Beaver Brook Project	2 years

47. HYDROLOGIC AND HYDRAULIC CONSIDERATIONS

a. General. - Hydrologic analyses of the major floods of record were made to determine the discharge contributions of the tributaries to flood peaks at the principal damage centers in order to evaluate the flood characteristics and potentialities of the various streams and the effectiveness of the proposed flood control projects. The discharges on Beaver Brook were determined from drainage area relationships with flows on Otter Brook and South Branch, while the stages on the Ashuelot River were based on steady-flow conditions related to the peak discharges at West Swanzey. Studies indicate that flood stages in the lower reaches of Beaver Brook are a combination of Ashuelot River stages and Beaver Brook discharges, and flood stages in the upper reaches are a function only of Beaver Brook discharges.

b. Flood Frequencies. - For use in the economic analysis, discharge frequency curves were developed in accordance with procedures published in ER 1110-2-1450, "Hydrologic Frequency Estimates", dated 10 October 1962. The discharge frequency curve for the Ashuelot River at West Swanzey was developed from the records of the U.S.G.S. gaging station at Hinsdale adopting a skew coefficient of 1.0, resulting in the flood of record having an annual chance of occurrence of 1.25 percent, or an average recurrence interval of 80 years. The discharge frequency curve for Beaver Brook was derived from correlations with gaging station records from the South Branch (Ashuelot River) and Otter Brook adopting a skew coefficient of 1.0, resulting in the flood of record having an annual chance of occurence of about 0.75 percent, or average recurrence interval of 133 years.

c. Standard Project Flood. - The standard project flood on Beaver Brook, as developed, has a peak inflow of 4500 cubic feet per second.

d. Spillway and Outlet Capacities. - The spillway design flood inflow was developed from the probable maximum precipitation and the adopted unit hydrograph resulting in a discharge peak of 6,000 c.f.s. and a surcharge of 6.3 feet. The outlet for purposes of flood control operation, is comparable to an ungated detention structure. The size and capacity of the conduit will be adequate (1) to pass normal stream flows; (2) to reduce flood flows; (3) to permit evacuation of the reservoir; (4) to pass a flood of considerable size during construction; (5) to inspect and maintain the conduit and water supply pipe.

48. EFFECT OF RESERVOIR REGULATION

The Beaver Brook Reservoir would act as an automatic detention basin since the sluice gate in the flood control outlet would be

pre-set and locked. The reservoir would be regulated to provide a high degree of protection from floods on Beaver Brook. It would have sufficient capacity to store the Standard Project Flood or a recurrence of the September 1938 flood of record. It is estimated that stages in the Roxbury-Church Street area, situated about 1 mile from the Ashuelot confluence, would be reduced 2 to 3 feet during minor and moderate floods. Further downstream on Beaver Brook in the Keene flood plain, stages are influenced by conditions in the Ashuelot River, so that stage reductions are somewhat less, varying from 1 to 2 feet.

49. PROVISIONS AGAINST ENCROACHMENT

Local interests would be required to provide assurances that stream encroachment lines will be established downstream from the recommended dam to permit non-damaging releases and reasonably efficient reservoir operation.

SECTION XIV - ESTIMATES OF FIRST COSTS AND ANNUAL CHARGES

50. FIRST COSTS

Unit prices used in estimating construction and relocation costs are based on average bid prices for similar work in the same general region, adjusted to the 1966 price level. Valuations of property are based on information from local officials and reflect values in recent sales in the area. All costs include an allowance for contingencies which has been carried as 15% in view of the extensive explorations and survey topography which was obtained during earlier detailed project studies. Costs of engineering and design are based on knowledge of the site and experience on similar projects. A summary of first costs for the recommended plan is given in Table 2.

51. ANNUAL CHARGES

Average annual charges, also summarized in Table 2, are based on interest rates of 3-1/8% for both Federal and non-Federal costs. Investment costs are amortized over the 100-year assumed life of the project. Allowances are made for costs of maintenance and operation and for interim replacement of equipment having an estimated life of less than 100 years. No allowance has been made for loss of taxes on land in Gilsum and in Keene as it is expected that enhancement of lands along the periphery of the proposed reservoir will offset any tax loss on land to be inundated.

TABLE 2

SUMMARY OF FIRST COSTS AND ANNUAL CHARGES '66 x 1.07 = '67 PL

BEAVER BROOK DAM AND RESERVOIR
(1966 Price Level)

First Costs		
Lands and Damages	$ 176,000	188,000
Relocations	180,000	193,000
Reservoir Clearing	69,000	74,000
Dams	613,000	656,000
Roads	11,500	12,000
Recreation Facilities	82,000	88,000
Engineering and Design	137,000(1)	146,000
Supervision and Administration	108,500	116,000
TOTAL PROJECT FIRST COSTS	$1,377,000 x 1.07 =	1,473,000
Annual Charges		
Interest and Amortization	$ 45,100	49,900
Maintenance and Operation	11,400	12,200
Major Replacements	1,200	1,300
TOTAL ANNUAL CHARGES	$ 57,700	$63,400

(1) Does not include preauthorization costs of $43,000.

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SECTION XV - ESTIMATES OF BENEFITS

52. FLOOD DAMAGE PREVENTION BENEFITS

The operation of Beaver Brook Dam and Reservoir would reduce flood damages along Beaver Brook and the Ashuelot River downstream of Keene. Annual benefits were derived along Beaver Brook by evaluating the difference in annual losses without flood protection and those remaining after project completion. On the lower reaches of Beaver Brook affected by backwater and on the Ashuelot River, annual benefits were computed for Beaver Brook Dam acting (1) next after the existing Surry Mountain and Otter Brook Dam and (2) next after the completed reservoirs and Honey Hill Dam on the South Branch (authorized but not built). Average annual benefits attributable to the Beaver Brook Project adjusted for the growth to occur over the next 20 years amount to $113,600, acting next after the existing Surry Mountain and Otter Brook Dams. In the alternate system, Beaver Brook acting next after Surry Mountain, Otter Brook, and the authorized but inactive Honey Hill Dam, annual benefits amount to $93,700.

53. RECREATION BENEFITS

Recreation benefits expected to accrue from the proposed water resource developments at Beaver Brook Dam were evaluated into two categories of general recreation and fishing. Under current New Hampshire State policy, contact sports are not permitted in domestic water supply reservoirs. Until Beaver Brook reservoir is to be used for water supply (estimated to be 20 years after project completion), full recreational use would be permitted as discussed in Appendix E.

a. General Recreation. - A survey of the recreational values of the areas affected by the proposed reservoir was made by Corps' personnel. The estimated average annual general recreation benefit, exclusive of fishing, is $37,500. When the reservoir is utilized for water supply, recreational use would be limited to such activities as picnicking, fishing, small boating and hiking. General recreation benefits based on the use of water supply at project year 20 amount to $29,800 annually as shown in Appendix E. Estimates are based on projected annual attendance and use of the recreation facilities to be provided.

b. Fish and Wildlife. - A survey of the fish and wildlife values of the areas affected by the proposed projects was made by the U. S. Fish and Wildlife Service. Benefits from Beaver Brook reservoir attributable to enhancement of sport fishery resources were determined by comparing the utilization of these resources expected to occur without the projects and that expected to occur with the projects in operation. The total estimated average annual benefits to fishery resources are $3,600. When the reservoir is utilized for water supply, fishing would be limited under current New Hampshire State policy. Benefits to fishery resources

based on the use of water supply at project year 20 amount to $2,200 annually as shown in Appendix E. Detrimental effects of the wildlife resources as produced by the development plan are expected to be mitigated by inclusion of a small water control structure and pool which might increase local waterfowl populations and attract other migrant waterfowl. No dollar benefit has been included for the waterfowl resource. Facilities would be provided to the extent justified by the damages prevented as discussed in Appendix E.

54. WATER SUPPLY BENEFITS

Table C-8, shown in Appendix C, outlines the method of determining annual water supply benefits and the annual costs of an equivalent, single-purpose water supply reservoir for cost allocation purposes, in accordance with standard Corps practice. These benefits were measured as the cost of obtaining the same quantity of water by the least costly alternative means that would most likely be developed in the absence of the Federal project. It is assumed that the reservoir would first be utilized for water supply 20 years after project completion. The discounted or average annual water supply benefits based on use of the pool from project year 20 to project year 100 (the assumed economic life of the project) amount to $20,100 annually.

55. INTANGIBLE BENEFITS

Certain intangible benefits which are not susceptible to direct monetary evaluation would be realized by the flood stage reduction provided by the project. These would benefit the public welfare by decreasing the threat to injury and loss of life. The stand-by potential of a dependable supply of water afforded by Beaver Brook Dam would promote an expansion of the industrial base in the area. In addition, the growth of the industrial base some of which is now located in the flood plain would be attracted by the removal of the flood threat.

Although intangible benefits of Beaver Brook would be of considerable magnitude, none have been evaluated for the purpose of this report. Letters from about 60 members of the Beaver Brook Association submitted at the Public Hearing were consistent in describing the extremely unsanitary conditions, the inconveniences and the interruption of facilities associated with flooding in the Beaver Brook area. Such conditions put increasing loads on the community, the costs of which are difficult to assess. The tangible evidences of health and economic growth spring from the intangible factors of confidence and optimism. These would be among the results of a dam and reservoir on Beaver Brook.

56. SUMMARY OF BENEFITS

The total annual benefits creditable to the project for flood control and allied purposes are summarized in Table 3.

TABLE 3

SUMMARY OF AVERAGE ANNUAL BENEFITS
(1966 Price Level)

Source of Benefit	
Flood Prevention	$113,600
Recreation	
General	29,800
Fishing	2,200
Water Supply	20,100
TOTAL ANNUAL BENEFITS	$165,700

SECTION XVI - PROJECT FORMULATION AND ECONOMIC JUSTIFICATION

57. GENERAL

The Beaver Brook multiple-purpose dam and reservoir, considered herein, will provide a practicable and economic means for the development of the water resources potential of the Beaver Brook watershed. Each of the purposes included in the project is adequately justified. The total first costs for the recommended multiple-purpose project, including flood control, recreation, and future water supply, is estimated at $1,377,000. The average annual charges amount to $57,700 with average annual flood prevention, recreation and water supply benefits amounting to $165,700 resulting in a benefit-cost ratio of 2.9 to 1. If the authorized Honey Hill Dam were to be built first, annual flood control benefits for the Beaver Brook project would decrease $19,900, resulting in a benefit-cost ratio of 2.5 to 1. Discussion of project formulation and economic analysis is included in Appendix C.

58. MAXIMIZATION OF NET BENEFITS

Maximization of net benefits for the flood control storages and water supply yields of the project is described in Appendix C. Benefits attributable to recreation are evaluated in Appendix E. A total of 25 combinations of varying flood control storages and water supply yields were evaluated in order to determine the point at which net benefits for the project were maximized. Costs, benefits and excess of benefits over costs were derived for all 25 plans. A graphic representation of the analysis is shown on Plate No. 3. The various water supply yields are plotted as functions of flood control storage vs. excess benefits.

The curves indicate that the point of maximization of net benefits would be achieved with a reservoir containing approximately 8.6 inches of flood control storage and water supply capable of yielding 4.0 million gallons per day (mgd) and was selected as the project to be recommended. A 98 percent dependable safe yield of 4.0 mgd will increase the existing supply to meet the peak demand of 11.0 mgd in the year 2010 forecast in the report of the Department of the Interior, Federal Water Pollution Control Administration included as Exhibit No. F-12 of Appendix F. Flood control storage of 2750 acre-feet will provide for 8.6 inches of runoff and would effectively control the standard project flood.

SECTION XVII - ALLOCATION AND APPORTIONMENT OF COSTS

59. ALLOCATION OF COSTS AMONG PURPOSES

Allocation of costs of the recommended multiple-purpose dam and reservoir to the purposes of flood control, water supply, and recreation were made by the separable costs-remaining benefit method. The total project cost is allocated among the three purposes in accordance with a standard procedure which distributes project costs among the purposes served so that all purposes share equitably in the savings of multiple-purpose construction. The cost allocated to each purpose is less than the corresponding benefits and each purpose is allocated at least its separable costs. Allocations among project purposes are as follows:

Purpose	First Cost	Annual Charges
Flood Control	$ 599,000	$23,300
Recreation	464,000	22,300
Future Water Supply	314,000	12,100
Total	$1,377,000	$57,700

60. APPORTIONMENT OF COSTS AMONG INTERESTS

a. Initial Cost Apportionment. - Table 4 shows the apportionment to Federal and non-Federal interests of first costs, annual charges, and annual operation, maintenance and replacement costs based upon present applicable laws and regulations governing cost-sharing practices. A brief description of the basis for apportionment is given in the following paragraphs:

(1) Flood Control. - Flood damage prevention benefits are principally realized within the city of Keene. The project is therefore considered a local protection project for which non-Federal interests are responsible for that portion of the costs of lands, damages, and relocations allocated to flood control in accordance with the 1936 Flood Control Act, as amended, an amount currently estimated at $192,000.

This is correct cost apportionment based on board action

TABLE 4

INITIAL COST APPORTIONMENT

	Federal	Non-Federal	Total
First Costs			
Flood Control			
Lands & Damages	$	$ 84,000	$ 84,000
Relocations		108,000	108,000
Dam & Reservoir	407,000		407,000
Totals - Flood Control	$407,000 436,000	$192,000 205,000	$ 599,000 641,000
Recreation			
Lands & Damages	$ 51,000	$	$ 51,000
Relocations	65,000		65,000
Dam & Reservoir	245,000		245,000
Recreation Facilities	51,500	51,500	103,000
Totals - Recreation	$412,500 441,000	$ 51,500 55,000	$ 464,000 496,000
Water Supply			
Lands & Damages	$	$ 41,000	$ 41,000
Relocations		53,000	53,000
Dam & Reservoir		200,000	200,000
Water Supply Features		20,000	20,000
Totals - Water Supply	$ 0	$314,000 336,000	$ 314,000 336,000
TOTAL FIRST COSTS	$819,500 877,000	$557,500 596,000	$1,377,000 1,473,000

	Interest & Amort.	Oper. & Maint.	Major Replacement	Total
Annual Charges				
Federal				
Flood Control	$13,300	$ 0	$ 0	$ 13,300
Recreation	13,500	0	0	13,500
Water Supply	0	0	0	0
Total - Federal	$26,800	$ 0	$ 0	$ 26,800
Non-Federal			O&M + Major Rep	
Flood Control	$ 6,300	$ 3,400	$ 300 3,700	$ 10,000
Recreation	1,700	6,600	500 7,100	8,800
Water Supply	10,300	1,400	400 1,800	12,100
Total - Non-Federal	$18,300	$11,400	$ 1,200 12,600	$ 30,900
TOTAL ANNUAL CHARGES	$45,100	$11,400	$ 1,200	$ 57,700

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(2) Recreation. - The Federal Water Project Recreation Act provides for a substantial level of Federal participation in the cost of development for recreation and fish and wildlife enhancement at projects such as the Beaver Brook Dam and Reservoir if non-Federal interests agree to administer project land and water areas for these purposes, bear not less than one-half of the separable project costs allocated thereto, and bear all the costs of operation, maintenance, and replacement of lands and facilities for recreation and fish and wildlife enhancement. The Act includes provisions for adoption of plans to reflect the intentions of non-Federal interests with respect to participation in the cost of recreation and fish and wildlife enhancement activities at various stages of project planning and implementation.

On the basis of the Act, local interests would be required to:

(a) Administer project land and water areas for recreation and fish and wildlife enhancement;

(b) Pay, contribute in kind, or repay (which may be through user fees) with interest, one-half of the separable cost of the project allocated to recreation and fish and wildlife enhancement, an amount currently estimated at $51,500; and

(c) Bear all costs of operation, maintenance, and replacement of lands and facilities for recreation and fish and wildlife enhancement an amount currently estimated at $7,100 on an average annual basis.

(3) Future Water Supply. - In order to provide for the most economical project, taking into account present and anticipated future costs, intake water lines, gate valves and a water line located inside the conduit outlet will be constructed coincidental with initial construction. These features have been included in the project at the request and for the benefit of the city of Keene and costs apportioned thereto are considered a non-Federal responsibility and subject to reimbursement at an estimated cost of $20,000.

Costs of the proposed project allocated to future water supply, currently estimated at $294,000 exclusive of the initial construction noted above, are reimbursable under the provisions of the Water Supply Act of 1958, as amended. The Act also stipulates that the costs of including the water supply facilities for anticipated future use and the allocated part of the joint construction costs of the project, should not exceed 30 percent of the total estimated construction cost of the project. Total costs of the project allocated to future water supply and for initially providing construction works for water supply facilities amounts to $314,000 or 22.8 percent of the total estimated project cost.

Annual operation and maintenance costs, and major capital replacement costs, will not be charged to future water supply until a contract is made for such future water supply and payments are initiated. It is anticipated that the reservoir would be utilized for water supply about 20 years after project completion. Until payments are initiated, operation, maintenance and replacement costs allocated to future water supply are assigned to the recreational function served by the project. In connection with the construction works presently included for future water supply, annual costs currently estimated at $1,800 for operation, maintenance and replacement of the project features would be borne by local interests.

b. Adjusted Cost Apportionment. - The initial cost apportionment (Table 4) indicates that the Federal Government would contribute toward the cost of lands, damages, and highway and utility relocations allocated to the project purpose of recreation. These costs, currently estimated at $116,000, have been adjusted in Table 5 to be the responsibility of non-Federal interests and a like amount is credited toward the non-Federal share of the apportioned water supply construction costs. Since non-Federal interests are responsible for the apportioned costs of lands, damages, and relocations in accordance with the Flood Control and Water Supply Acts, it is considered in the best interests of the Federal Government, in connection with assurances of local cooperation, that non-Federal interests bear costs of all lands, damages and relocations.

SECTION XVIII - PROPOSED LOCAL COOPERATION

61. GENERAL

As discussed above, local interests would be required to provide, without cost to the United States, all lands, easements, and rights-of-way necessary for the construction and operation of the local protection project, hold and save the United States free from damages due to the construction works; and maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army. Under the requirements of lands, easements,and rights-of-way, acquisition of land rights required for spoil disposal areas would also be the responsibility of local interests, as would the necessary relocation of State Highway Route 10 including utilities and the transmission line crossing the reservoir. Federal-aid highway funds cannot be used to defray any part of the costs for highway relocations for water resource projects where local interests are required to assume the cost of such adjustment as part of the local construction. Spoil disposal areas would be required for excess topsoil, unacceptable rock excavation and fines and screenings from grizzling. Spoil areas will be located in the project area and designated in final design stages.

State and city officials have indicated a willingness and ability to fulfill the conditions of local cooperation as attested by Exhibit Letters in Appendix F.

In accordance with the Federal Water Project Recreation Act, Public Law 89-72, non-Federal interests would be required to administer project

TABLE 5

ADJUSTED COST APPORTIONMENT

	Federal	Non-Federal	Total
First Costs			
Flood Control			
Lands & Damages	$	$ 84,000	$ 84,000
Relocations		108,000	108,000
Dam & Reservoir	407,000		407,000
Totals - Flood Control	$407,000 436,000	$ 192,000 205,000	$ 599,000 641,000
Recreation			
Lands & Damages	$	$ 51,000	$ 51,000
Relocations		65,000	65,000
Dam & Reservoir	245,000		245,000
Recreation Facilities	51,500	51,500	103,000
Totals - Recreation	$296,500 317,000	$ 167,500 179,000	$ 464,000 496,000
Water Supply			
Lands & Damages	$	$ 41,000	$ 41,000
Relocations		53,000	53,000
Dam & Reservoir	116,000	84,000	200,000
Water Supply Features		20,000	20,000
Totals - Water Supply	$116,000 124,000	$ 198,000 212,000	$ 314,000 336,000
TOTAL FIRST COSTS	$819,500 877,000	$ 557,500 596,000	$1,377,000 1,473,000

	Interest & Amort.	Oper. & Maint.	Major Replacement	Total
Annual Charges				
Federal				
Flood Control	$13,300	$ 0	$ 0	$ 13,300
Recreation	9,700	0	0	9,700
Water Supply	3,800	0	0	3,800
Total - Federal	$26,800	$ 0	$ 0	$ 26,800
Non-Federal				
Flood Control	$ 6,300	$ 3,400	$ 300	$ 10,000
Recreation	5,500	6,600	500	12,600
Water Supply	6,500	1,400	400	8,300
Total - Non-Federal	$18,300	$ 11,400	$ 1,200	$ 30,900
TOTAL ANNUAL CHARGES	$45,100	$ 11,400	$ 1,200	$ 57,700

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land and water areas for recreation and fish and wildlife enhancement; pay, contribute in kind, or repay with interest, one-half of the separable cost of the project allocated to recreation and fish and wildlife enhancement; and bear all costs of operation, maintenance and replacement of lands and facilities for recreation and fish and wildlife enhancement.

In accordance with the Water Supply Act of 1958, as amended, local interests would be required to pay for project costs assigned to the water supply features of the project, and assume full responsibility and bear all costs of operation, maintenance and replacement of the project features presently included for future water supply and at such time as the reservoir is utilized for water supply, assume the cost of operation, maintenance and replacement allocated to water supply and reimburse the Federal Government for their apportioned share of water supply cost.

Non-Federal interests would also be required to protect channels downstream from the reservoir to permit efficient reservoir operation and exercise to the full extent of their legal capability, control against removal of water in the watershed which will affect the reservoir's water supply storage and the development of dependable stream regulations.

SECTION XIX - COORDINATION WITH OTHER AGENCIES

62. GENERAL

Coordination with all Federal, State and local agencies having an interest in the proposed improvement was carried out during the course of the studies. The agencies reviewed the plans for the project considered and furnished comments and recommendations relative to the phase of development in which they have a primary interest. The suggestions and recommendations made by these agencies for meeting the various needs have generally been followed in the formulation and development of the project. Letters of comment are included in Appendix F of this report.

SECTION XX - DISCUSSION

63. FLOOD PROBLEMS

Flood protection for the city of Keene is needed. Industrial, commercial and residential properties have suffered substantial damages from the effects of past floods, resulting in disruption of the city's economy and danger to public health and safety from pollution from backed-up sewers. The record flood of September 1938, the most damaging experienced in the Ashuelot River Basin, caused losses amounting to $1,138,000.

Approximately $515,000 of this amount was sustained within the city of Keene which includes $218,000 encountered along Beaver Brook. A more recent damaging flood occurred in April 1960, and caused losses estimated at $100,000 along Beaver Brook in Keene. A recurrence of the experienced 1938 flood levels would cause losses amounting to $3,120,000 on Beaver Brook alone. Operation of the existing flood control dams at Surry Mountain and Otter Brook would prevent $1,245,000 of these losses and nearly all of the remainder would be prevented by construction of Beaver Brook Dam.

64. SOLUTIONS CONSIDERED

All practicable methods for solving the flood problems were considered. These included local protection measures and channel improvements, diversion and relocation of Beaver Brook, modification of the dam at West Swanzey, channel improvement of the Ashuelot River, flood plain zoning, and evacuation and resettlement. These methods were found to be impracticable due to the extensive costs involved or economically infeasible at this time.

65. RECOMMENDED PLAN

The formulated plan providing the most practicable and economic means for development of the water resources potential of the watershed consists of a multiple-purpose storage reservoir on Beaver Brook in Keene, New Hampshire. Project formulation and economic analysis is discussed in Appendix C. The reservoir would reduce flood damages, meet an expanding recreation need, and provide a source of future water supply for the city of Keene. In a recurrence of the 1938 flood under current conditions, the Beaver Brook project would prevent losses of $1,700,000 in the Ashuelot River Basin and $1,655,000 on Beaver Brook. The estimated total first cost of the recommended multiple-purpose project including flood control, recreation, and future water supply is $1,377,000 with average annual charges of $57,700. Average annual flood prevention, water supply and recreation benefits are $165,700 resulting in a benefit-cost ratio of 2.9 to 1.

66. SENATE RESOLUTION 148

Additional information on recommended and alternative projects called for by Senate Resolution 148, 85th Congress, 1st Session, adopted 28 January 1958, is contained in Attachment II to this report.

SECTION XXI - CONCLUSIONS AND RECOMMENDATIONS

67. CONCLUSIONS

As a result of studies made for this report, it is concluded that construction of a multiple-purpose dam and reservoir on Beaver Brook in

Keene, New Hampshire, essentially as described in this report is warranted. The improvement presented has been planned for maximum utilization of the site for development of the water resources in the area. The site can be developed for flood control and recreational purposes with the added potential of converting recreation storage to future water supply. The proposed project would reduce future flood damages, satisfy some of the demands for increased recreational facilities and provide a source of water supply for the city of Keene for future use. The Beaver Brook multiple-purpose dam and reservoir is amply justified by evaluated benefits and meets the desires of local interests. Furthermore, in the event that the water supply needs of the city become so acute as to dictate the use of storage provided for recreation at an early date, those specific costs assigned to recreation will not be completely lost since only water contact sports would be eliminated in the recreation purpose.

68. RECOMMENDATIONS

The Division Engineer recommends that the plan for the control of floods in the Connecticut River Basin approved by the Act of June 22, 1936 (Public Law Numbered 738, Seventy-fourth Congress) as amended and supplemented, be further modified to provide for the construction of a multiple-purpose dam and reservoir on Beaver Brook, in the city of Keene, New Hampshire, including flood control, recreation, fish and wildlife conservation and future water supply, essentially as described in this report, with such modifications as the Chief of Engineers considers advisable, at an estimated total first cost of $1,377,000 for construction, exclusive of preauthorization costs, and average annual costs of $57,700 including provisions for operation, maintenance and major replacements.

He further recommends that prior to initiation of construction of the Beaver Brook Dam and Reservoir, non-Federal interests give assurances satisfactory to the Secretary of the Army that they will:

1. Provide without cost to the United States, all lands, easements, and rights-of-way necessary for the construction and operation of the project currently estimated at $176,000;

2. Hold and save the United States free from damages due to the construction works;

3. Maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army;

4. Provide without cost to the United States all alterations, replacements and relocations of existing utilities and highways currently estimated at $226,000;

5. In accordance with the Federal Water Project Recreation Act, Public Law 89-72:

a. Administer project land and water areas for recreation and fish and wildlife enhancement;

b. Pay, contribute in kind, or repay (which may be through user fees) with interest, one-half of the separable cost of the project allocated to recreation and fish and wildlife enhancement, an amount currently estimated at $51,500 consisting of $48,000 for general recreation and $3,500 for fishing;

c. Bear all costs of operation, maintenance and replacement of lands and facilities for recreation and fish and wildlife enhancement, an amount currently estimated at $7,100 on an average annual basis. Provided, that the sizing and responsibility for development, operation, maintenance, and replacement of the recreation and fish and wildlife enhancement features of the reservoir may be modified in accordance with the alternatives provided in the Water Project Recreation Act, depending upon the intentions of non-Federal interests regarding participation in the costs of these features at the time of reservoir construction and subsequent thereto, and that appropriate adjustments reflecting such modifications may be made in the allocation of costs to other project purposes.

6. Prior to construction of the water supply features, agree in accord with the Water Supply Act of 1958, as amended to:

a. Reimburse the United States for that portion of the construction costs allocated to future water supply, amounting to $104,000. This reimbursement shall be made within the life of the project, but in no event shall the repayment period exceed 50 years after the project is first used for water supply purposes, except that no payment need be made on this amount or interest charged thereon until storage is first used for water supply purposes, but in no event shall the interest-free period exceed 10 years;

b. Assume full responsibility and bear all costs of operation, maintenance and replacement of the project features presently included for future water supply. At such time as the reservoir is utilized for water supply, assume cost of operation, maintenance and replacement allocated to water supply.

7. Obtain water rights necessary for the use of stored water for water supply purposes and hold the Government harmless from liability for or on account of any claim for damages which may be made or asserted as the result of the storage and withdrawal of water by the user. Use of the water shall be in a manner consistent with Federal and State laws;

8. Protect channels downstream from the reservoir from encroachments which would adversely affect reservoir operation; and,

9. Exercise to the full extent of their legal capability, control against removal of water in the watershed which will affect the reservoir's water supply storage and the development of dependable stream regulations.

The ultimate Federal first cost for the Beaver Brook multiple-purpose dam and reservoir, exclusive of preauthorization costs, is currently estimated at $819,500 the non-Federal first cost is estimated at $557,500. The Federal appropriation requirement is presently estimated at $975,000 including reimbursable costs of $104,000 and $51,500 for water supply and recreation, respectively. Net average annual costs for operation, maintenance and major replacements which are items of local responsibility, are estimated at $12,600.

11 Incls
1. Plate No. 1
2. Plate No. 2
3. Plate No. 3
4. Plate No. 4
5.)Appendices
10.) A-F
11. Attachment I - Digest of Public Hearing
12. Attachment II - S-148 Supplement

REMI O. RENIER
Colonel, Corps of Engineers
Acting Division Engineer

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ACKNOWLEDGEMENTS AND IDENTIFICATION OF PERSONNEL

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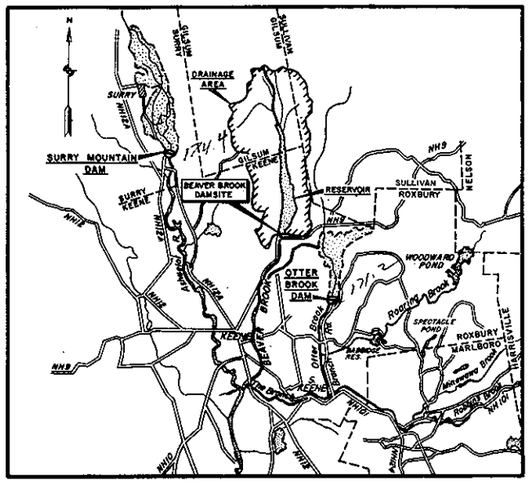
2. This report was prepared under the direction of Carmine N. Ciriello, Chief, Small Projects Section.

3. The U. S. Army Engineer Division, New England, is appreciative of the cooperation rendered in connection with this study by personnel of other Federal agencies, State agencies and local interests.

CORPS OF ENGINEERS

U.S. ARMY



VICINITY MAP

SCALE IN FEET

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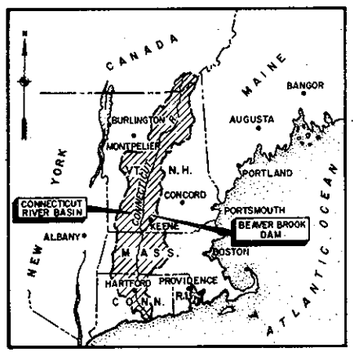

LOCATION MAP

SCALE IN MILES

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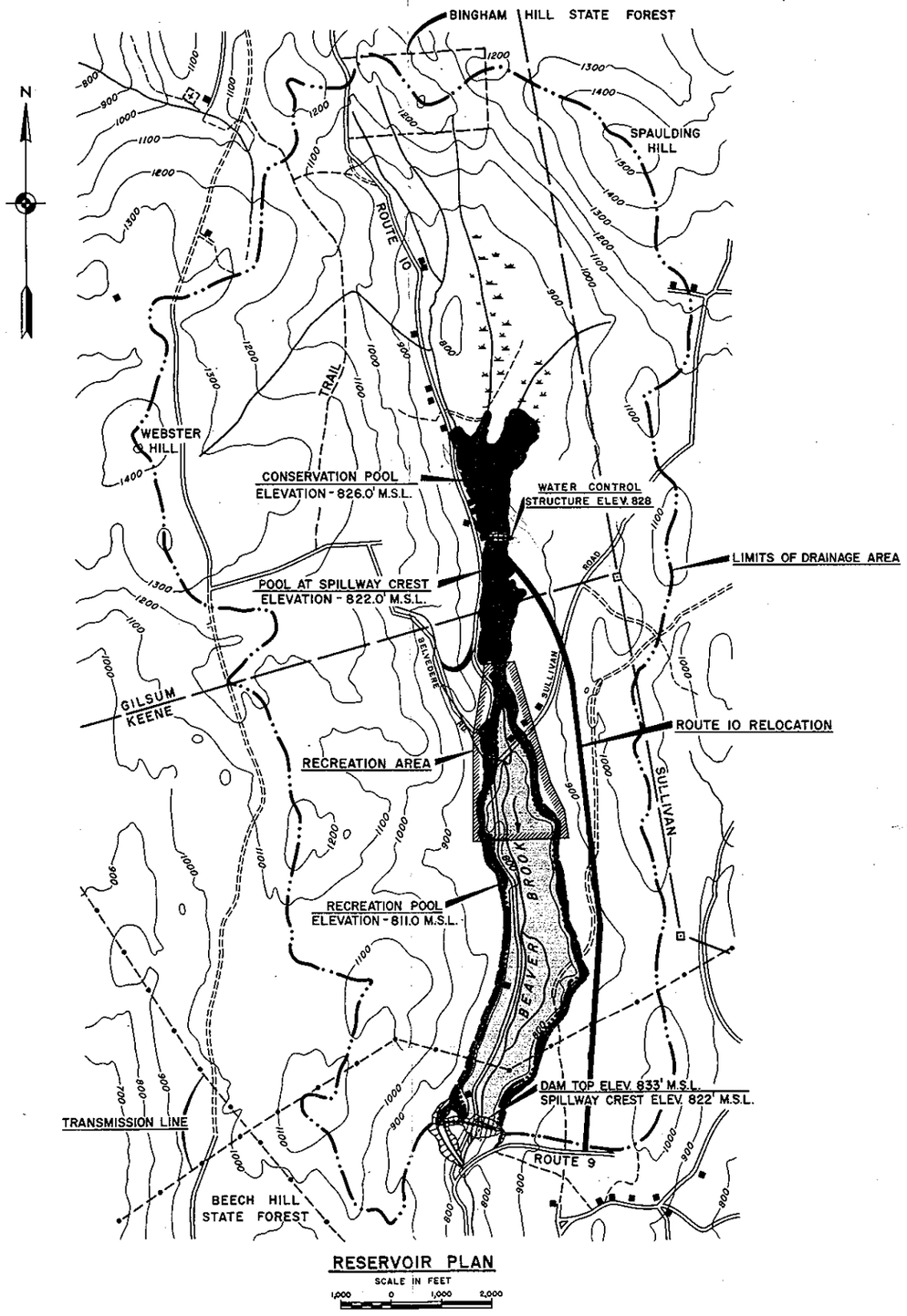

RESERVOIR PLAN

SCALE IN FEET

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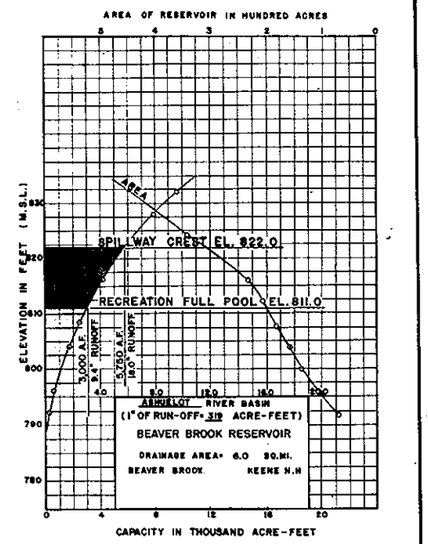
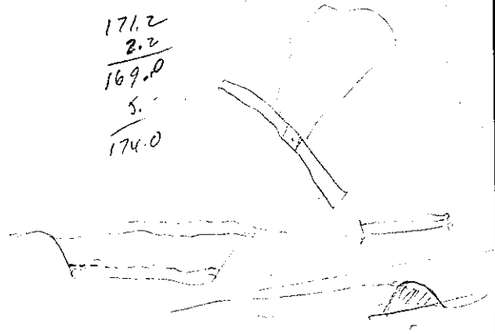


AREA AND CAPACITY CURVES

Control at dam

171.2
2.2
169.0
5.
174.0



NOTE:

Route 10 in reservoir area to be relocated.
115 KV Transmission line to be relocated (6,000 L.F.).
Elevations refer to Mean Sea Level Datum.
Topography is based on Nov.-Dec. 1964 and Jan. 1965 survey by U.S. Army Corps of Engineers.

REVISION	DATE	DESCRIPTION	BY
A	3-6-67	Reservoir Plan and Vicinity Map Revised	

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY F.W.S. | DR. BY M.S. | CK. BY

C.K. Cristello
PROJECT ENGINEER

CHIEF, ENGINEERING DIVISION

CHIEF, P.B.R. BRANCH

CONNECTICUT RIVER FLOOD CONTROL
KEENE, NEW HAMPSHIRE
BEAVER BROOK DAM
DRAINAGE AREA AND RESERVOIR PLAN
BEAVER BROOK, NEW HAMPSHIRE

APPROVED

DATE NOV. 1966

TO ACCOMPANY REPORT
DATED: NOVEMBER 1966

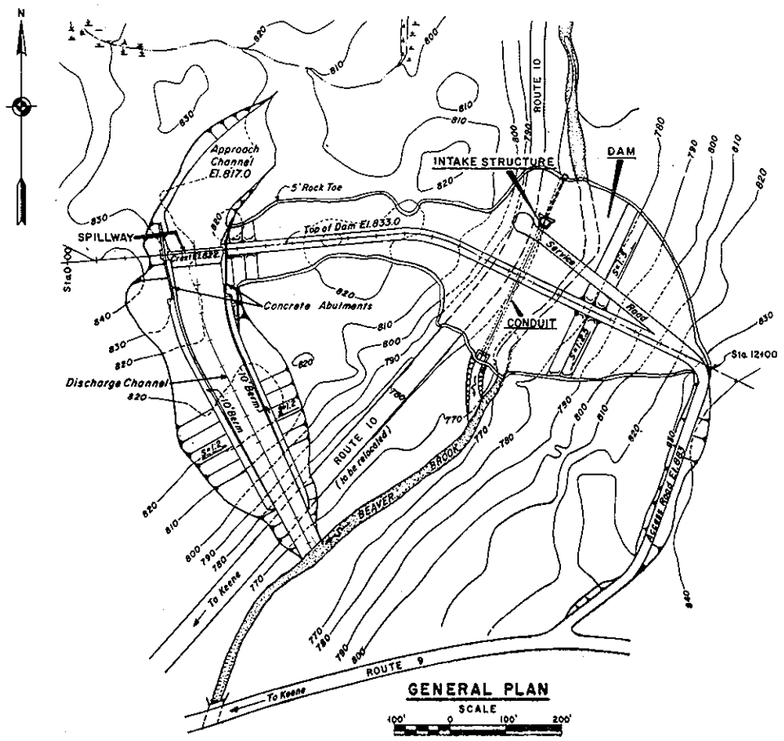
SCALE: AS SHOWN

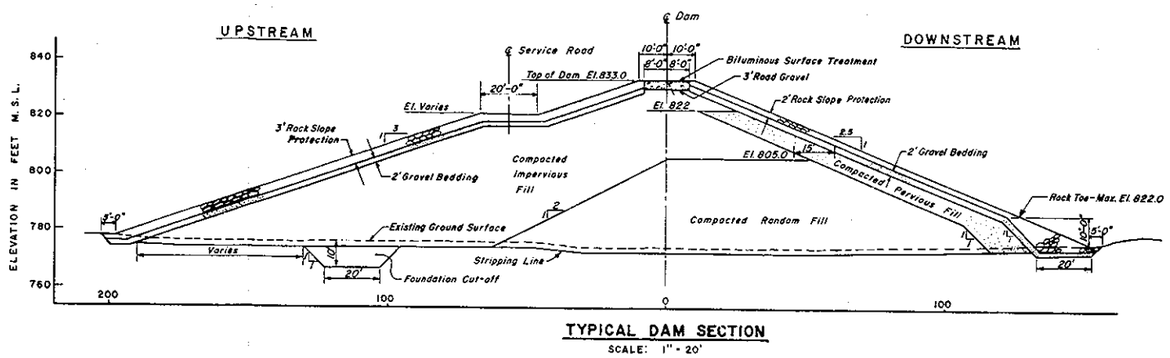
DRAWING NUMBER

PLATE NO. 1

CORPS OF ENGINEERS

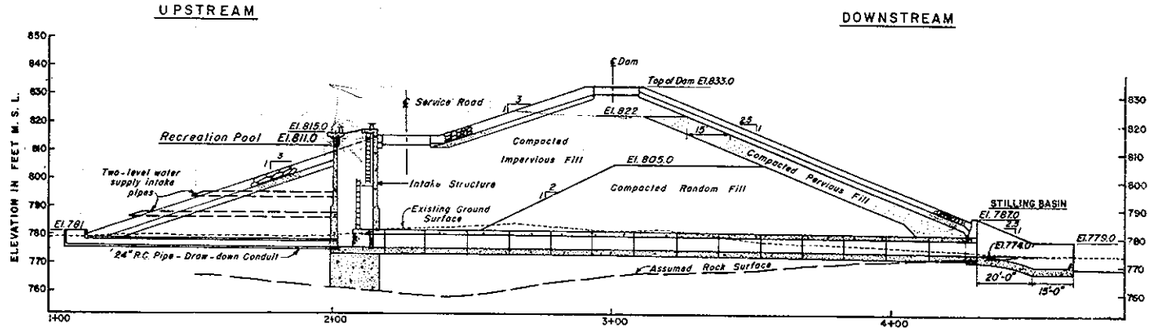
U. S. ARMY





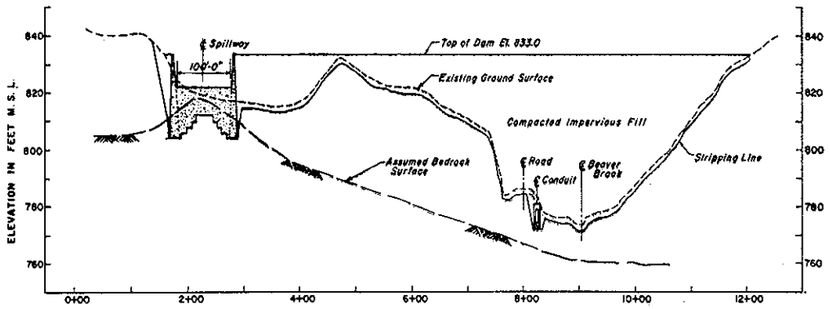
TYPICAL DAM SECTION

SCALE: 1" = 20'



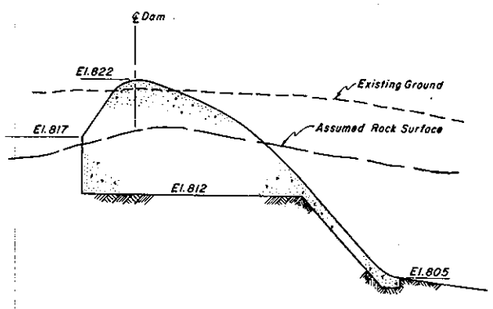
PROFILE ALONG ℄ CONDUIT

SCALE IN FEET
20' 0 20' 40'



PROFILE THROUGH ℄ DAM

SCALE: 1" = 100' HORZ.
1" = 20' VERT.



SECTION ALONG CENTER LINE OF SPILLWAY WEIR

SCALE IN FEET
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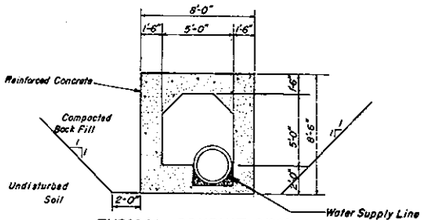
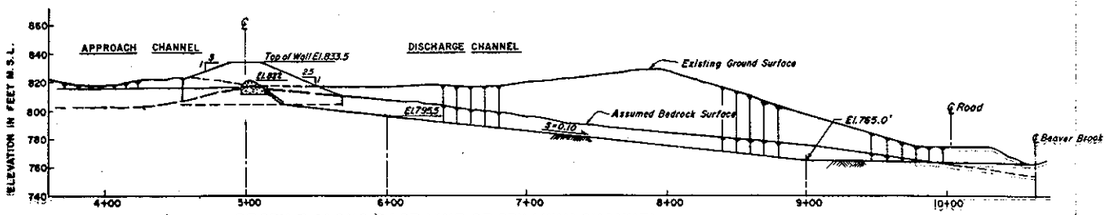


TYPICAL CONDUIT SECTION

SCALE IN FEET
4' 0 4' 8'



PROFILE ALONG BASE LINE OF SPILLWAY CHANNEL

SCALE: 1" = 40'

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY	DR. BY	CK. BY
F.W.S.	M.W.B.	

C.H. Smith
PROJECT ENGINEER

RECOMMENDED:
CHIEF, ENGR. DIV.

CHIEF, P. & P. BRANCH

CONNECTICUT RIVER FLOOD CONTROL
KEENE, NEW HAMPSHIRE

BEAVER BROOK DAM
GENERAL PLAN AND SECTIONS
BEAVER BROOK, NEW HAMPSHIRE

APPROVED:
CHIEF, ENGINEERING DIVISION

DATE: NOV. 1966

SCALE AS SHOWN

DRAWING NUMBER

TO ACCOMPANY REPORT
DATED: NOVEMBER 1966

PLATE NO. 2

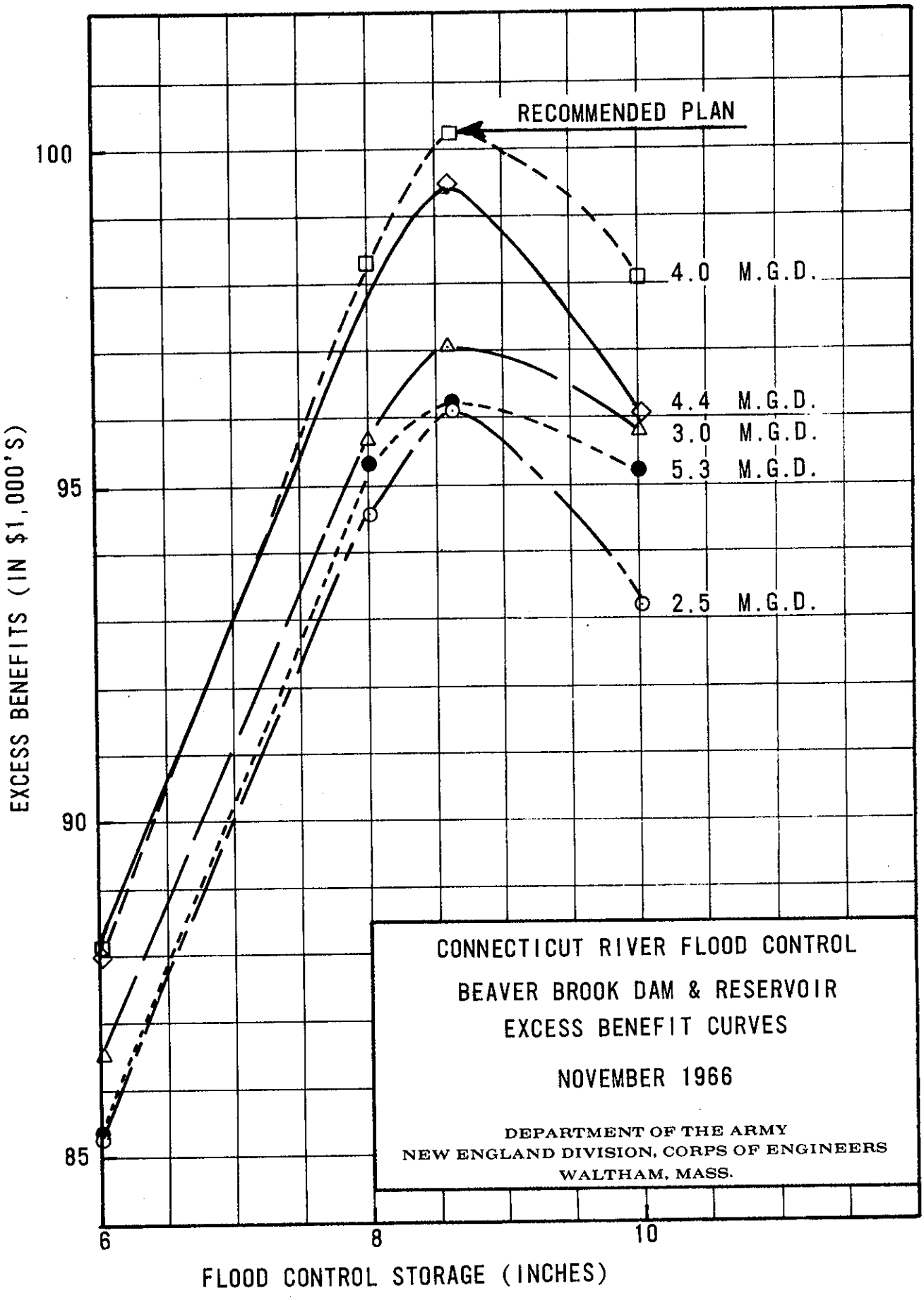
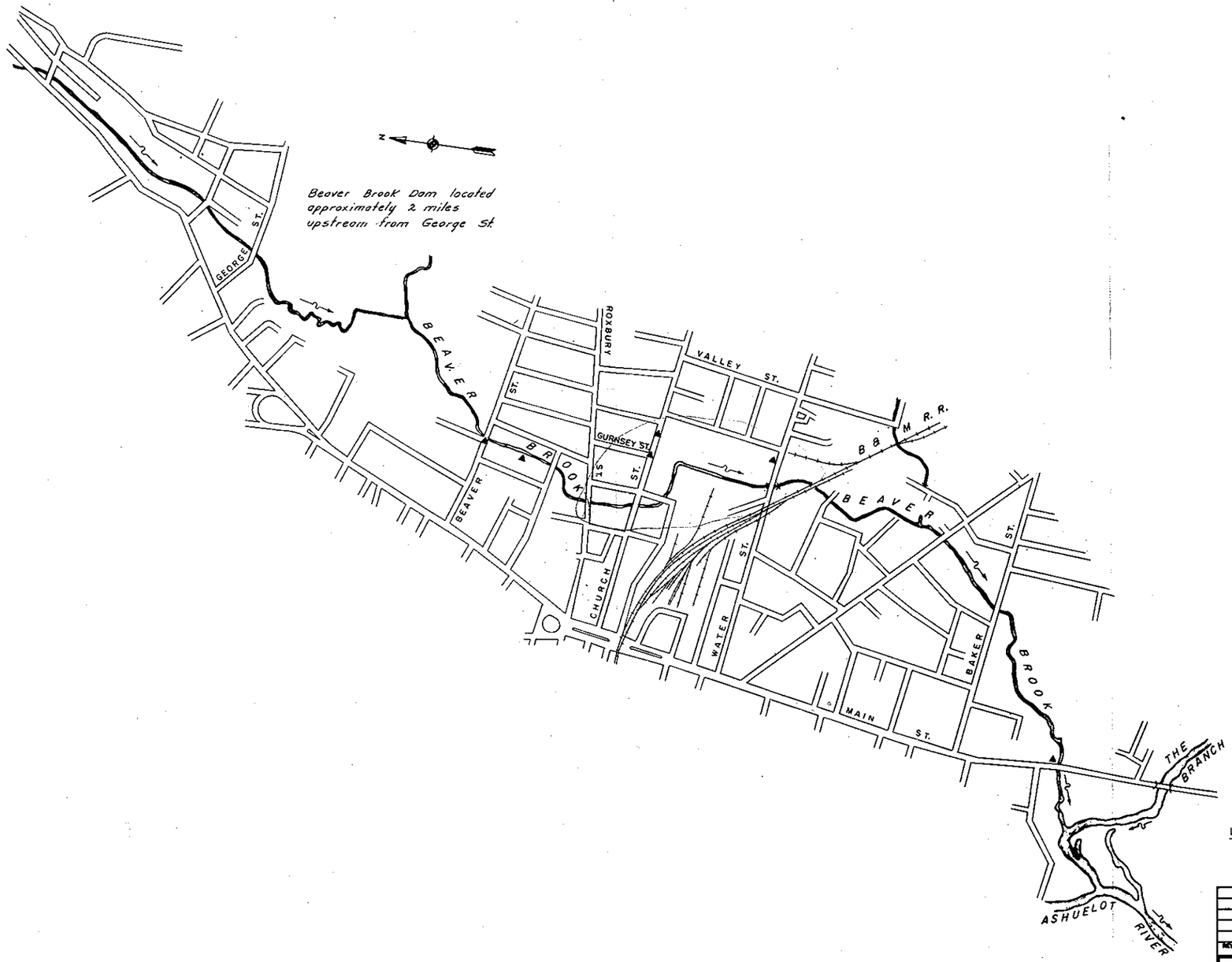

RECOMMENDED PLAN
100
95
90
85
4.0 M.G.D.
4.4 M.G.D.
3.0 M.G.D.
5.3 M.G.D.
2.5 M.G.D.
EXCESS BENEFITS (IN $1,000'S)
6
8
10
FLOOD CONTROL STORAGE (INCHES)
CONNECTICUT RIVER FLOOD CONTROL
BEAVER BROOK DAM & RESERVOIR
EXCESS BENEFIT CURVES
NOVEMBER 1966
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE NO. 3

CORPS OF ENGINEERS — U. S. ARMY



LEGEND

▲ Flood photo locations

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY C.M.O. | CK. BY

PROJECT ENGINEER

CHIEF, SMALL PROJECTS BRANCH

APPROVED

CHIEF, PLANS & SPECS BRANCH

CONNECTICUT RIVER FLOOD CONTROL
KEENE NEW HAMPSHIRE
STREET LAYOUT IN THE VICINITY OF BEAVER BROOK
BEAVER BROOK NEW HAMPSHIRE

APPROVED DATE

CHIEF, ENGINEERING DIVISION

SCALE | SPEC. NO. CIV. ENG. 19-016-
DRAWING NUMBER

SHEET

PLATE NO. 4

APPENDIX A

FLOOD LOSSES AND BENEFITS

APPENDIX A

FLOOD LOSSES AND BENEFITS

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A-2	DAMAGE-FREQUENCY, BEAVER BROOK, ZONE III
A-3	DAMAGE-FREQUENCY, BEAVER BROOK, ZONE III

APPENDIX A

FLOOD LOSSES AND BENEFITS

1. DAMAGE SURVEYS

Damage surveys were initially conducted throughout the Ashuelot River Basin following the September 1938 flood and were later supplemented by reviews in 1947 and 1953, undertaken to check the change and extent of development within the flood plain. The latest damage survey, made after the April 1960 flood, was confined to the flood area along Beaver Brook in the City of Keene. In view of the higher stages previously experienced during the September 1938 flood, estimates of recurring losses were obtained for both the 1938 and 1960 flood crests.

Damage surveys comprised door-to-door inspections and interviews of the several hundred residential, commercial, industrial and other properties affected by flooding. The recorded information included the extent of the areas flooded, descriptions of properties, nature and amount of damage, depth of flooding, high-water references and relationships to prior flood stages. Estimated evaluations of damages were generally furnished by property owners. Investigators applied their own judgement in modifying these estimates and also made estimates when the owner or tenants were not available.

Sufficient data was obtained to derive losses for: (1) the 1960 and 1938 flood crests; (2) stages 1 to 2 feet higher than the 1938 flood; and (3) intermediate stages where marked changes in damage occurred.

2. LOSS CLASSIFICATION

Flood loss information was recorded by type of loss and location. Loss types used were industrial; urban, comprising commercial, residential, and public; rural; highway; and railroad. Losses evaluated included (1) physical losses, such as damage to structures, machinery and stock, and the cost of cleanup and repairs, and (2) non-physical losses, such as unrecoverable loss of business and wages, cost of temporary facilities and increased cost of operation. Losses resulting from physical damages and a large part of the related non-physical losses were determined by direct inspection of property and evaluation of losses by the property owners and/or field investigators. Where non-physical portions of losses

could not be determined from available data, estimates were based upon the relationship between physical and non-physical losses for similar properties in the area. No evaluations were made of intangible damages including such items as loss of life, hazards to public health, and impairment of national security.

3. FLOOD DAMAGES

The record flood of September 1938 resulted in an estimated loss of nearly $1,138,000 in the Ashuelot River Basin. Over 1,200 families were forced from their homes, and 150 commercial and industrial properties were badly damaged. Keene, New Hampshire, the largest community in the watershed, sustained losses amounting to about $515,000. Of this amount, $218,000 was encountered along Beaver Brook, where flood stages reached as high as 5 feet over first floor levels. Some 372 properties were affected, including 347 homes, 15 commercial firms and 10 industrial plants.

Downstream of Keene, industrial, commercial, residential, and rural areas in the Towns of Swanzey, Winchester, and Hinsdale were heavily damaged with flood stages reaching 2 to 3 feet above first floor levels. Affected were some 9 industrial firms, 16 commercial establishments, 29 residences, and 63 agricultural properties. Total damages in the 3 communities amounted to $387,300. Highway losses attributable to the flood amounted to 28 percent of the total basin loss. Table A-I shows the 1938 experienced flood losses in the Ashuelot River Basin by town and type of loss.

The most recent flood to strike Keene occurred in April 1960, when Beaver Brook overtopped its banks. Some 267 properties sustained losses amounting to nearly $100,000. Included in this loss were some 249 homes, 11 industrial firms, and 7 commercial establishments. Operation of the existing Surry Mountain and Otter Brook flood control dams prevented additional losses.

TABLE A-I

Experienced September 1938 Flood Losses

Ashuelot River Basin

Town	Urban	Industrial	Rural	Highway	Railroad	Total
Hinsdale	$ 900	$ 12,500	$ -	$ 14,200	$ 2,400	$ 30,000
Keene	163,200	227,900	25,800	56,000	42,000	514,900
Marlboro	8,700	27,900	1,400	75,400	-	113,400
Swanzey	3,100	38,500	18,100	20,400	8,000	88,100
Winchester	75,600	131,800	20,600	33,200	8,000	269,200
Other Towns on tributaries unaffected by projects	-	-	-	118,200	4,200	122,400
	$251,500	$438,600	$65,900	$317,400	$64,600	$1,138,000

4. RECURRING AND PREVENTABLE LOSSES

A recurrence of September 1938 flood stages in the Ashuelot River Basin under present conditions would cause an estimated loss of $5,450,000 without flood protection. Damages along Beaver Brook would amount to $3,120,000, representing about 57 percent of the total basin loss. Operation of the existing flood control dams at Surry Mountain and Otter Brook would reduce damages from $5,450,000 to $3,080,000. Of this residual loss, $1,700,000 would be eliminated with the construction of the recommended Beaver Brook Dam and Reservoir. In the alternate system, the authorized Honey Hill Dam in conjunction with the existing dams at Surry Mountain and Otter Brook would reduce losses from $5,450,000 to $2,175,000. Adding Beaver Brook Dam and Reservoir to the system would provide additional savings of $1,240,000. Tables A-II and A-III show recurring September 1938 losses without flood protection and losses preventable by the existing, authorized and recommended flood control dams.

5. AVERAGE ANNUAL LOSSES

Annual losses were derived for the reaches downstream of the proposed Beaver Brook Dam site by utilizing stage-damage, stage-discharge and discharge-frequency data to develop damage-frequency curves. The area under these curves, which have been plotted with damage as the ordinate and with percent-chance-of-occurrence as the abscissa, is a measure of the average annual loss. The average annual loss in the reaches below the proposed Beaver Brook Dam site in the Ashuelot River Basin totals $462,300 without flood protection. Of this loss, $205,600 occurs on Beaver Brook and $256,700 on the damage zones of the Ashuelot River downstream of the Surry Mountain and Otter Brook Dams. Operation of these dams which have been constructed will reduce annual losses on Beaver Brook to $93,800 and losses on the Ashuelot River zones to $51,000, resulting in a total modified annual loss of $144,800.

TABLE A-II

Flood of September 1938 - Ashuelot River Basin

Description of Damage Reaches - Recurring and Preventable Losses

(1965 Price Level)

Reach Description	Recurring Losses	Losses Preventable by existing Surry Mountain and Otter Brook Dams	Losses Preventable by recommended Beaver Brook Dam after Surry Mountain and Otter Brook Dams	Losses Preventable by authorized Honey Hill Dam after Surry Mountain, Otter Brook and Beaver Brook Dams	Residual Loss
				1,875,000	
Beaver Brook - Beaver Brook Damsite to mouth	$3,120,000	$1,245,000	$1,655,000	$130,000	$ 90,000
Ashuelot River - Surry Mountain Dam to mouth of South Branch River	725,000	615,000	15,000	80,000	15,000
	Jay Keene (3,845,000)	(1,860,000	1,670,000		
Ashuelot River - Mouth of South Branch River to mouth of Wheelock Brook	125,000	80,000	5,000	40,000	-
Ashuelot River - Mouth of Wheelock Brook to mouth of Ashuelot River	650,000	430,000	25,000	195,000	-
Tributaries	830,000	-	-	-	830,000
TOTAL	$5,450,000	$2,370,000	$1,700,000	$445,000	$935,000

increase 20% for 65 PL - 69 PL

10% for 69 PL - 70 PL.

TABLE A-III

Flood of September 1938 - Ashuelot River Basin

Description of Damage Reaches - Recurring and Preventable Losses

(1965 Price Level)

Reach Description	Recurring Losses	Losses Preventable by existing Surry Mountain and Otter Brook Dams	Additional Losses Preventable by authorized Honey Hill Dam	Losses Preventable by Beaver Brook Dam after Surry Mountain, Otter Brook, and Honey Hill Dams	Residual Loss
Beaver Brook - Beaver Brook Dam site to mouth	$3,120,000	$1,245,000	$620,000	$1,165,000	$ 90,000
Ashuelot River - Surry Mountain Dam to mouth of South Branch River	725,000	615,000	95,000	-	15,000
Ashuelot River - Mouth of South Branch River to mouth of Wheelock Brook	125,000	80,000	45,000	-	-
Ashuelot River - Mouth of Wheelock Brook to mouth of Ashuelot River	650,000	430,000	145,000	75,000	-
Tributaries	830,000	-	-	-	830,000
TOTAL	$5,450,000	$2,370,000	$905,000	$1,240,000	$935,000

6. TRENDS OF DEVELOPMENT

Keene has been a commercial and industrial center for Cheshire County and the western portion of the center of New Hampshire for many years. Review of statistics for manufactures, retail trade, and population reveal that the City of Keene has followed the county and the State in a steady economic growth over the past three decades which is exceeded only by the rates of growth of the Gross National Product and the national population. Table A-IV includes pertinent data as to economic parameters. The older industries have held their own or been replaced by new enterprises. The machine tool and wood products industries have expanded and electronics and plastic plants have moved into the area. Commercial establishments have participated in this growth. The flood plain along Beaver Brook and its confluence with the Ashuelot River has been the site of construction of several industrial establishments in the past twenty years. Availability of land in the flood plain, together with trends exhibited, lead to the conclusion that flood losses will grow at the rate of 1.5 percent per year for the next twenty years before the available lands are fully utilized. Conversion of this growth to an annual equivalent basis over the project life of 100 years results in annual benefits for growth amounting to $19,900 ($15,500 in the alternate system).

The growth experienced during the past twenty years, which is continuing today and is expected to continue without additional flood protection, will not be materially hastened by project construction. Consequently, no enhancement benefits have been evaluated.

TABLE A-IV

Economic Parameters

Keene, New Hampshire

	1930	1940	1950	1960	1965	1970	1980
Gross National Product (millions of actual dollars)	91,105	100,680	284,599	504,400	649,000	790,000*	934,000**
National Population (millions)	122.8	131.7	150.7	180.7	196.0* 176.3#	214.0* 183.2#	254.0**
New Hampshire Population (thousands)	465.3	491.5	533.2	606.9			
Cheshire County Population (thousands)	33.7	34.9	38.8	43.3			
Keene, New Hampshire Population (thousands)	13.8	13.8	15.6	17.6			

* National Planning Association Projections
** Ad Hoc Water Resources Council Projection
\# NENYIAC Projection

Value Added by Manufacture	1939	1947	1954	1958	1963
New Hampshire, thousands of (1963 dollars)	254,133	435,843	478,326	520,152	654,075
Cheshire County, New Hampshire, thousands of (1963 dollars)	22,255	34,081	40,917	49,494	53,229
Keene, New Hampshire, thousands of (1963 dollars)	9,804	16,435	21,711	29,118	(1)

(1) Not available.

Retail Sales	1948	1954	1958	1963
New Hampshire, thousands of (1963 dollars)	608,232	706,669	745,727	881,814
Cheshire County, New Hampshire, thousands of (1963 dollars)	38,829	43,662	48,128	61,999
Keene, New Hampshire, thousands of (1963 dollars)	25,683	28,961	32,050	40,218

7. AVERAGE ANNUAL BENEFITS

Average annual benefits were derived for the existing Surry Mountain and Otter Brook Reservoirs, the authorized Honey Hill Reservoir, and the recommended Beaver Brook Reservoir by applying estimates of flow reductions, developed by hydrologic analysis, to annual loss data previously computed. The benefits for the Beaver Brook Reservoir were computed on 2 bases: (1) acting next after the completed reservoirs; and (2) acting after both the completed and authorized reservoirs which would affect flood flows and stages in the Ashuelot River Basin. The basic benefit was adjusted upward by 22.4% to reflect the growth projected to occur in the areas of project influence over the next 20 years.

Operation of Beaver Brook Dam and Reservoir, acting next after Surry Mountain and Otter Brook Reservoirs, would result in average annual benefits of $108,600 in the Ashuelot River Basin. Of this total benefit, $103,400 would be realized on Beaver Brook and $5,200 in the reaches of the Ashuelot River downstream from Keene. In addition, benefits attributable to Beaver Brook Reservoir on the Connecticut River were computed with Beaver Brook acting last in the existing system of reservoirs. These benefits amount to $5,000 annually.

Operation of the alternate system, Beaver Brook Dam acting next after Surry Mountain, Otter Brook, and Honey Hill Reservoirs, would result in average annual benefits amounting to $88,700. Annual benefits totalling $86,900 would be realized on Beaver Brook and $1,800 on the Ashuelot River.

Derivation of average annual losses and benefits are illustrated on Plates A-I, A-II, and A-III for a typical zone in Keene. Table A-V shows benefits to Beaver Brook Dam acting after the two alternative systems.

TABLE A-V

Average Annual Losses and Benefits to Beaver Brook Reservoir

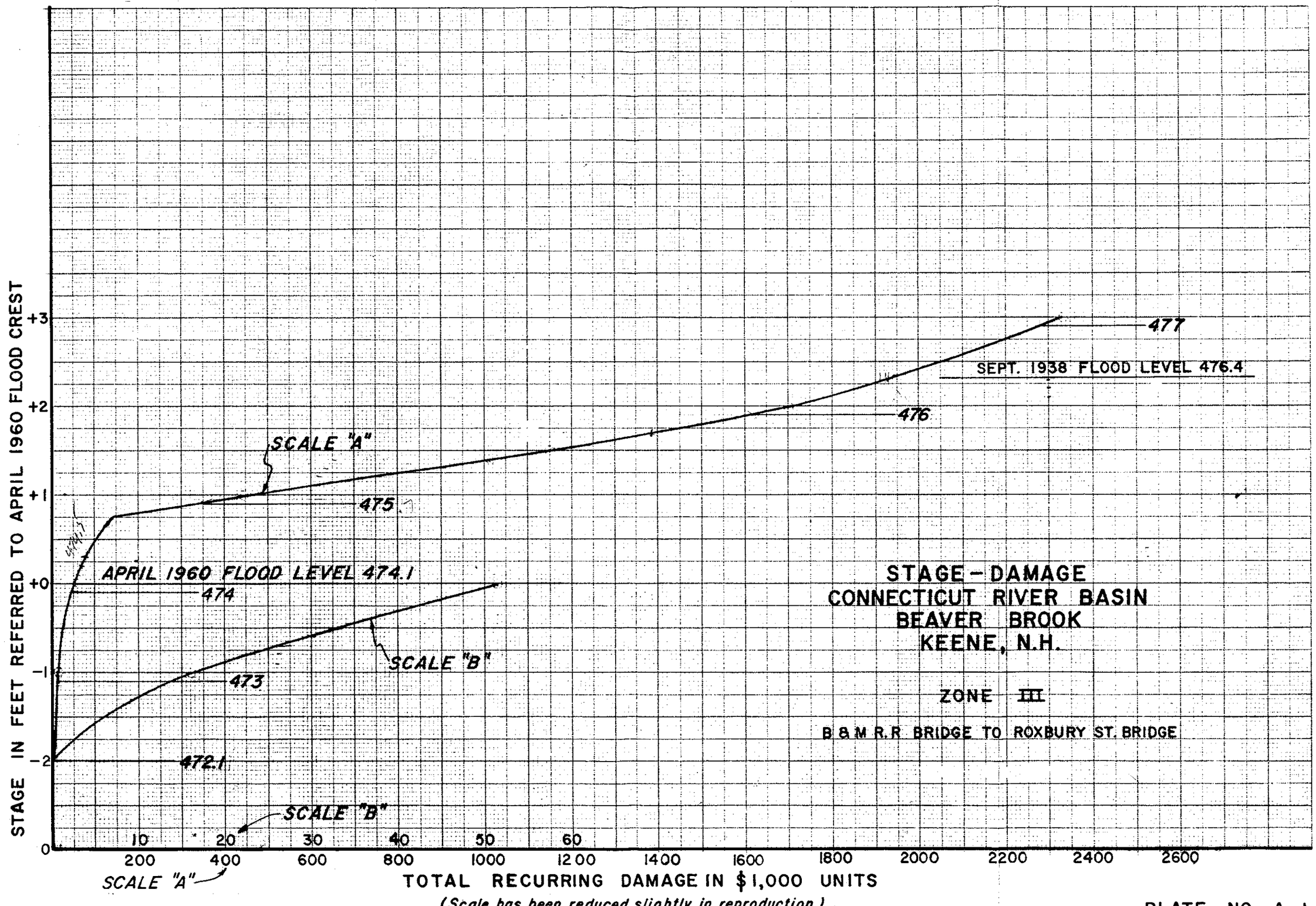
Ashuelot River Basin

(1965 Price Level)

Reach Description	ANNUAL LOSSES		ANNUAL BENEFITS	
	Natural Average Annual Loss	Annual Loss Modified by Surry Mountain & Otter Brook Dams	Beaver Brook Dam next after Surry Mountain & Otter Brook Dams	Beaver Brook Dam next after Surry Mountain, Otter Brook & Honey Hill Dams
Beaver Brook - Beaver Brook Dam site to mouth	$205,600	$ 93,800	$103,400*	$86,900*
Ashuelot River - Surry Mountain Dam to mouth of South Branch River	154,200	25,900	3,300*	1,100*
Ashuelot River - Mouth of South Branch River to mouth of Wheelock Brook	18,400	2,800	400*	100*
Ashuelot River - Mouth of Wheelock Brook to mouth of Ashuelot River	84,100	22,300	1,500*	600*
TOTAL - ASHUELOT RIVER BASIN**	$462,300	$144,800	$108,600**	$88,700**

* Adjusted to reflect growth during the next 20 years with appropriate discounting for the growth period.

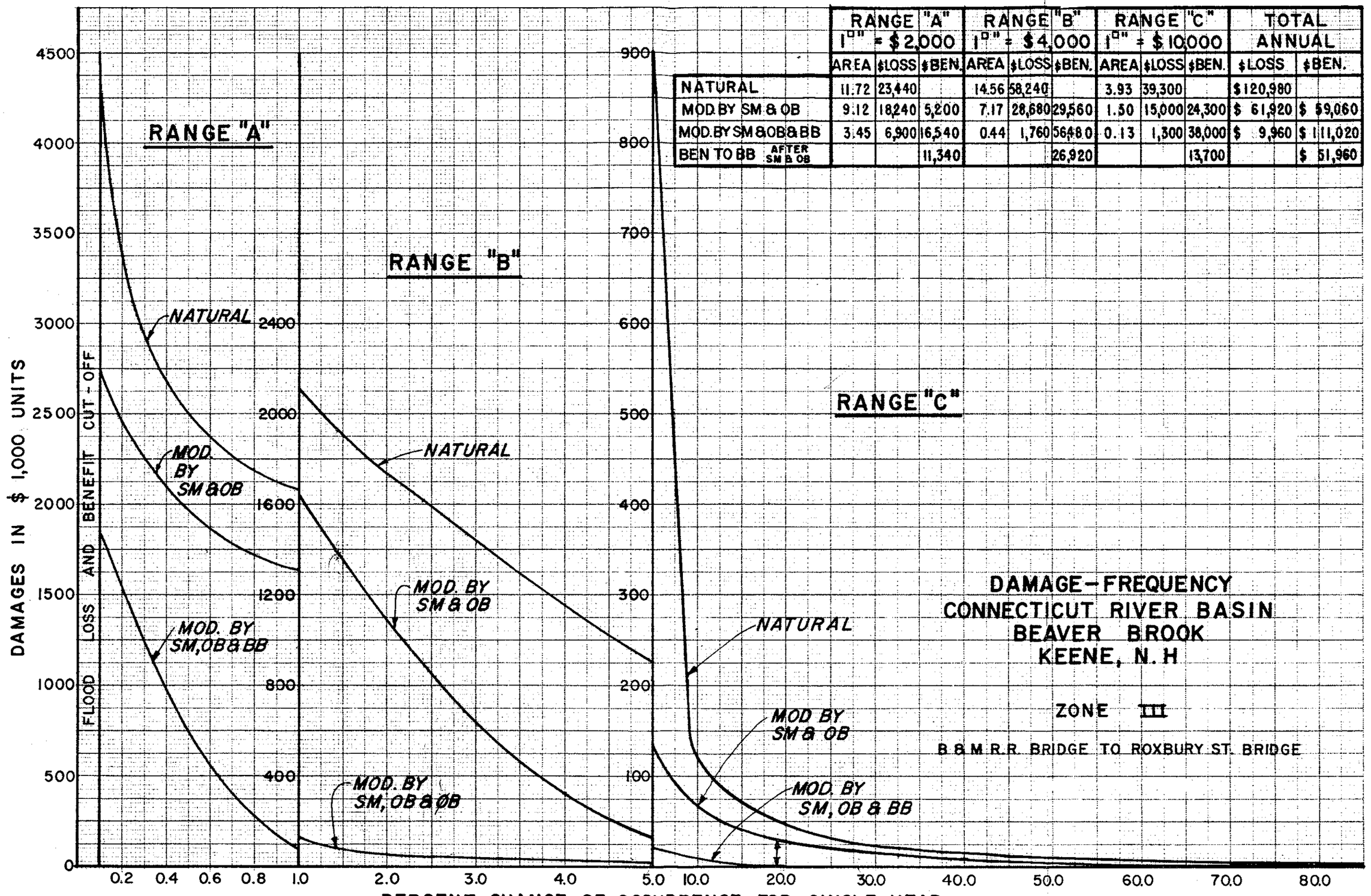
** In addition, benefits, attributable to Beaver Brook Reservoir, on the Connecticut River amount to $5,000 annually.



(Scale has been reduced slightly in reproduction)

PLATE NO. A-1

	RANGE "A" 1" = $2,000			RANGE "B" 1" = $4,000			RANGE "C" 1" = $10,000			TOTAL ANNUAL	
	AREA	$LOSS	$BEN.	AREA	$LOSS	$BEN.	AREA	$LOSS	$BEN.	$LOSS	$BEN.
NATURAL	11.72	23,440		14.56	58,240		3.93	39,300		$120,980	
MOD. BY SM & OB	9.12	18,240	5,200	7.17	28,680	29,560	1.50	15,000	24,300	$ 61,920	$ 59,060
MOD. BY SM & OB & BB	3.45	6,900	16,540	0.44	1,760	56480	0.13	1,300	38,000	$ 9,960	$ 111,020
BEN TO BB AFTER SM & OB			11,340			26,920			13,700		$ 51,960



DAMAGE-FREQUENCY
CONNECTICUT RIVER BASIN
BEAVER BROOK
KEENE, N.H

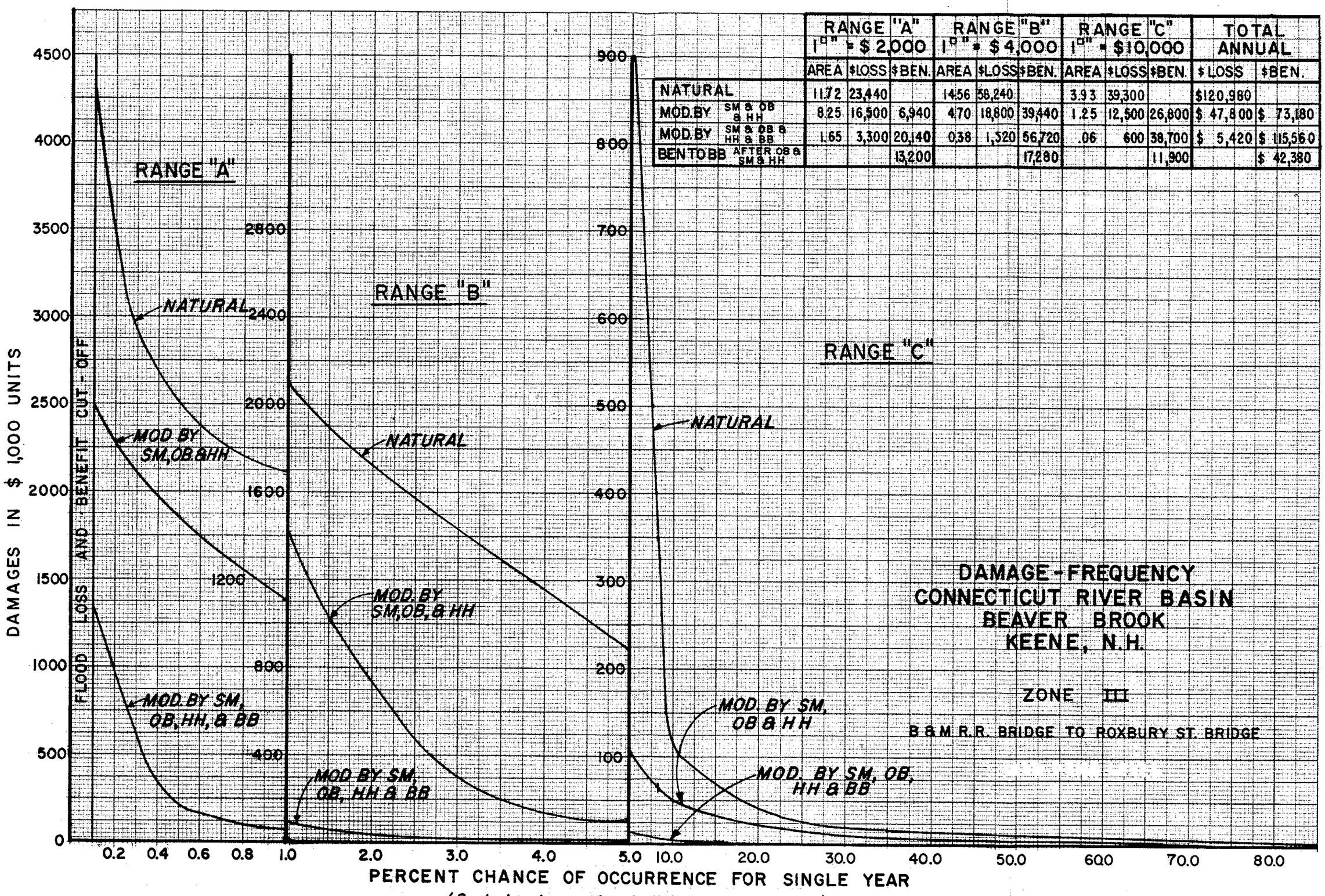
ZONE III

B & M R.R. BRIDGE TO ROXBURY ST. BRIDGE

(Scale has been reduced slightly in reproduction)

PLATE NO. A-2

	RANGE "A" 1" = $ 2,000			RANGE "B" 1" = $ 4,000			RANGE "C" 1" = $10,000			TOTAL ANNUAL	
	AREA	$LOSS	$BEN.	AREA	$LOSS	$BEN.	AREA	$LOSS	$BEN.	$ LOSS	$BEN.
NATURAL	11.72	23,440		14.56	38,240		3.93	39,300		$120,980	
MOD. BY SM & OB & HH	8.25	16,500	6,940	4.70	18,800	39,440	1.25	12,500	26,800	$ 47,800	$ 73,180
MOD. BY SM & OB & HH & BB	1.65	3,300	20,140	0.38	1,520	56,720	.06	600	38,700	$ 5,420	$ 115,560
BEN TO BB AFTER OB & SM & HH			13,200			17,280			11,900		$ 42,380



DAMAGE - FREQUENCY
CONNECTICUT RIVER BASIN
BEAVER BROOK
KEENE, N.H.

ZONE III

B & M R.R. BRIDGE TO ROXBURY ST. BRIDGE

(Scale has been reduced slightly in reproduction)

PLATE NO. A-3

APPENDIX B

HYDROLOGY AND HYDRAULICS

APPENDIX B

HYDROLOGY AND HYDRAULICS

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HYDROLOGY AND HYDRAULICS

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APPENDIX B

HYDROLOGY AND HYDRAULICS

1. INTRODUCTION

This appendix presents climatological and hydrological data on the Ashuelot River watershed, along with the analysis of floods of record, the development of synthetic floods and the determination of flood reduction afforded by different systems of reservoirs.

2. BASIN DESCRIPTION

a. Ashuelot River

The Ashuelot River lies in the southwest corner of New Hampshire, where it drains an area of 421 square miles at its confluence with the Connecticut River near Hinsdale. Generally, the watershed is hilly, with low mountains in the headwaters. A few natural lakes and ponds are also found in the area. The river has a total fall of 1,475 feet in its length of 64 miles, but much of this drop is concentrated near the headwaters (Plate B-1).

b. Main Tributaries

The two main tributaries of the Ashuelot River are the Branch and the South Branch. The Branch, entering the Ashuelot River just below Keene, New Hampshire, about 26.5 miles upstream from the mouth, is formed by the confluence of Minnewawa Brook and Otter Brook. The South Branch joins the Ashuelot River just above Swanzey Station, or about 23.5 miles upstream from the mouth.

c. Keene Flood Plain

The portion of the Ashuelot River between the Faulkner and Colony Company Dam in Keene and the Dickinson Dam in West Swanzey is referred to as the Keene Flood Plain. The meandering river channel in the flood plain has low discharge capacity due to its small cross-sectional area and flat gradients, with the result that flood waters cause considerable depth of pondage. About 75 percent of the Ashuelot River drainage area empties into this reach of the river. Table B-1 lists the approximate drainage areas of the streams that discharge into the flood plain.

TABLE B-1

KEENE, NEW HAMPSHIRE FLOOD PLAIN - DRAINAGE AREAS

Location		Drainage Area in Square Miles
Ashuelot River at the Branch		114
The Branch at mouth		100
Otter Brook at the Branch	55	
Minnewawa Brook at the Branch	33	
Beaver Brook at the Branch	10	
South Branch Ashuelot at mouth		72
Ash Swamp Brook at mouth		18
Local Drainage - Keene to West Swanzey		8
TOTAL at West Swanzey		312

d. Beaver Brook

Beaver Brook, with a drainage area of 10 square miles, flows southward through the City of Keene and joins the Branch near its mouth in the flood plain (Shown on Plates B-2 and B-3). The watershed is rectangular in shape, with a length of about 7 miles and a width of about 1.5 miles. It has basically a single stream pattern with short side tributaries with steep slopes. This is evident from the drainage area and stream profile shown on Plate B-4. Although Beaver Brook has a total fall of over 1,000 feet in about 8 miles of length, the lower 2 miles in the City of Keene and that portion in the vicinity of the proposed dam are relatively flat.

Downstream of the damsite for about two miles, the channel is fairly steep with considerable discharge capacity. However, once the brook reaches the outer limits of the populated areas, the stream bed flattens out and it enters into a flood plain with a width that varies from 500 to 2000 feet. The channel depth throughout the remaining two-mile length to the mouth is approximately 5 feet. The channel capacity through this reach is estimated to be 120 c.f.s. (about 15 c.s.m.). Discharges in excess of this result in overbank flooding with ponding developing over a large area.

3. CLIMATOLOGY

a. General

The Ashuelot River Watershed has a variable climate, characterized by frequent but generally short periods of heavy

precipitation. It lies in the path of the "prevailing westerlies" and is exposed to the cyclonic disturbances that cross the country from the west or southwest. The area is also subject to coastal storms that travel up the Atlantic seaboard in the form of hurricanes of tropical origin and storms of extra-tropical nature, often called "northeasters". The winters are moderately severe, with sub-zero temperatures rather common. The Spring melting of the winter snow cover occurs generally in late March or April.

b. Temperatures

The mean annual temperature at Keene, New Hampshire, is approximately 45°F, with the average monthly temperature varying from about 70°F in July to near 20°F in January. Extremes in temperature range from highs slightly in excess of 100°F to lows in the minus thirties. Table B-2 summarizes mean, maximum, and minimum monthly temperatures recorded each month at Keene, New Hampshire, for 72 years of record through 1964.

TABLE B-2

MONTHLY TEMPERATURES AT KEENE, NEW HAMPSHIRE
(Degrees Fahrenheit)

Month	Mean	Maximum	Minimum
January	21.5	66	-32
February	22.5	65	-32
March	32.8	85	-21
April	44.4	91	1
May	55.8	95	21
June	64.4	98	27
July	69.3	104	34
August	66.9	102	27
September	59.8	101	19
October	49.3	90	10
November	37.5	80	-15
December	25.3	64	-29
Annual	45.8	104	-32

c. Precipitation

1. General. - The mean annual precipitation at Keene, New Hampshire is 38.7 inches. The greatest annual precipitation recorded

was 51.2 inches in 1951 and the least annual amount was 27.1 inches, recorded in 1894. Table B-3 summarizes the precipitation on record at Keene, New Hampshire, for 73 years of record through 1964.

TABLE B-3

MONTHLY PRECIPITATION AT KEENE, NEW HAMPSHIRE
Elevation 490 feet, M.S.L.
(Depth in Inches)

Month	Mean	Maximum	Minimum
January	2.98	6.50	0.85
February	2.66	7.02	0.60
March	3.18	7.60	0.04
April	3.16	6.65	0.35
May	3.27	7.02	0.79
June	3.38	7.73	0.41
July	3.74	11.09	1.07
August	3.62	8.96	1.05
September	3.53	10.39	0.20
October	2.76	7.84	0.23
November	3.33	7.67	0.52
December	3.04	6.70	0.51
Annual	38.7	51.2	27.1

2. Snow. - Monthly and annual average snowfall at Keene, New Hampshire, for 66 years of record through 1964 is shown in Table B-4.

TABLE B-4

MEAN MONTHLY SNOWFALL AT KEENE, NEW HAMPSHIRE
(Elevation 500 feet, m.s.l.)

Month	Depth in Inches	Month	Depth in Inches
January	16.6	July	-
February	16.3	August	-
March	11.2	September	-
April	3.2	October	0.1
May	-	November	3.6
June	-	December	11.3

Annual 62.3

Snow courses have been established above the watersheds of Surry Mt. and Otter Brook Reservoirs to give an index of the water equivalent of the snow, which is used as a guide in the regulation of the reservoirs during the periods of snowmelt. A summary of the water equivalent during the winter and spring months is shown in Table B-5.

TABLE B-5

WATER EQUIVALENT IN SNOW COVER
(Depth in Inches)

Date	Mean	Maximum	Minimum
1 February	2.9	5.5	0.9
15 February	3.7	7.7	0.8
1 March	4.5	8.5	0.7
15 March	5.2	9.4	1.0
1 April	3.8	8.8	-
15 April	1.2	6.5	-

4. STREAMFLOW

a. General

The U.S. Geological Survey has published records of river stages and streamflows at 5 locations in the Ashuelot River watershed for various periods from 1907 through 1963 (summarized in Table B-6 on following page). The records are generally good to excellent except those for periods of ice effect or no gage-height record. There is no published record of streamflow on Beaver Brook. However, a temporary recording gage has been installed on Beaver Brook in the City of Keene and is located in the Woodland Cemetery about 800 feet upstream of Beaver Street (see Plates No. B-2 and B-4). This gage, which has a drainage area of 8.25 square miles, was established to gather statistical data for the proposed Beaver Brook project and has been in operation since October 1962.

b. Stream Runoff

Inasmuch as the Beaver Brook records are available for only a few years, the runoff records for both Otter Brook and the South Branch are considered indicative of flows on Beaver Brook. The annual runoff for 40 years of record for the Otter Brook gaging station varied from 12.63 inches to 32.93 inches, with a mean of 22.54 inches. The mean annual runoff represents about 60 percent of the

TABLE B-6

STREAMFLOW RECORDS

Location of Gaging Station	Drainage Area (sq.mi.)	Period of Record	Discharge Mean (cfs)	Discharge Maximum (cfs)	Discharge Minimum (cfs)
Ashuelot River at Hinsdale, New Hampshire	420	Mar. 1907-	657	16,600	10
South Branch Ashuelot River at Webb, New Hampshire	36.0	Oct. 1920-	59.4	5,960	0.1
Otter Brook below Dam near Keene, New Hampshire	47.2	May 1958	77.7	685	0.1
Otter Brook near Keene, New Hampshire *	42.3	Oct. 1923- Sep. 1957	71.0	6,130	1.0
Ashuelot River below Surry Mt. Dam near Keene, New Hampshire	101	Sep. 1945	172	1,320	0.4
Ashuelot River at Gilsum, New Hampshire	71.1	Aug. 1922-	125	5,220	1.0

* Gaging station relocated downstream of Otter Brook Dam.

TABLE B-7

MONTHLY RUNOFF

(Otter Brook Gage - Keene, New Hampshire)

Month	Maximum (Inches)	Minimum (Inches)	Mean (Inches)
January	4.10	0.16	1.75
February	3.31	0.33	1.07
March	12.00	0.63	3.28
April	11.51	1.79	6.06
May	5.99	0.88	2.77
June	4.67	0.33	1.31
July	3.98	0.09	0.66
August	2.30	0.05	0.46
September	9.00	0.05	0.79
October	3.69	0.08	0.84
November	5.83	0.19	1.73
December	4.20	0.38	1.82
ANNUAL	32.93	12.63	22.54

mean annual precipitation. A summary of the maximum, minimum, and mean monthly runoff in inches is shown in Table B-7.

c. Low Flow Analysis

The discharge records of the nearby South Branch gaging station were analyzed in order to determine the yield and dependability of flow on Beaver Brook. The recorded average annual flow approximates 1.7 cubic feet per second per square mile, resulting in a mean flow of about 10.2 cfs at the Beaver Brook damsite.

Curves of storage versus draft, in percent of average annual runoff, with frequency curves as parameters were developed for the South Branch gaging station. From these, curves of yield versus storage for various frequencies were computed for Beaver Brook and are shown on Plate B-11. Consideration was given to the effect of evaporation and was found to be minor. For example, with a full pool storage of 3,000 acre-feet, the loss in a critical dry year during the months of July and August would be equivalent to a flow of about 0.72 cfs or a volume about 85 acre-feet.

5. FLOODS OF RECORD

a. General

Outstanding floods on the Ashuelot River may result from early spring storms combined with melting snow, such as the flood of March 1936, or from summer or fall storms, such as the record flood of September 1938. In addition, local thunderstorms can cause serious flash floods on the smaller streams.

b. Flood History

1. Ashuelot River. - The Ashuelot River watershed has experienced seven major floods in recent years. Table B-8 shows the peak discharges of these floods at the U. S. Geological Survey Gaging stations at Ashuelot River at Gilsum, New Hampshire, South Branch Ashuelot River at Webb, New Hampshire, and Otter Brook near Keene, New Hampshire. Also included is an estimate of peak discharges on Beaver Brook at Marlboro Street.

TABLE B-8

FLOODS OF RECORD
Peak Flow (cfs)

Flood	Ashuelot R. at Gilsum, N. H. (71.1 sq. mi.)	So. Branch at Webb, N. H. (36.0 sq. mi.)	Otter Brook near Keene, N.H. (42.3 sq. mi.)	Beaver Brook at Marlboro Street (9.5 sq. mi.)
Nov. 1927	2,760	3,560	3,180	-
Apr. 1934	3,490	1,010	3,020	-
Mar. 1936	4,400	3,880	3,580	900*
Sep. 1938	5,220	5,960	6,130	2,200*
Nov. 1950	3,700	2,010	3,540	500*
Oct. 1959	2,700	4,350	5,000*	600*
Apr. 1960	2,800	2,290	2,000*	600*

* Estimated Flow.

The November 1927 flood resulted from rainfall of 4 to 5 inches falling on ground saturated from excessive rains during the previous month. The April 1934 flood combined heavy rains with considerable snowmelt. The flood of March 1936 is the second largest of record in the Ashuelot River watershed and resulted from two major rainstorms which, combined with heavy snowmelt, caused two major rises in river stages only six days apart. The largest flood of record occurred in September 1938 when a hurricane passed over the watershed. Rainfall accompanying this storm combined with precipitation of the previous three days totalled more than 10 inches. The November 1950 flood was a result of 3 to 4 inches of intense rainfall on previously wet ground. The October 1959 flood which produced substantial peaks on the Branch and South Branch rivers, was a result of about 4 inches of rain in 24 hours. The April 1960 flood occurred when 3 to 4 inches of rain fell on snow with a high water content. During this flood stages on lower Beaver Brook were also affected by backwater from the Ashuelot River.

2. Beaver Brook. - A review of the records of the City of Keene reveals that flooding on Beaver Brook has been a recurring problem since the earliest times. Periodically, at five to ten-year intervals since 1813, the brook has flooded extensive areas from Beaver Street mouth to Main Street. The accounts of high water in recent times since 1900 includes references to amounts of rainfall and it appears that a rainfall of more than two inches in 24 hours results in overbank flooding on the brook. Following is a chronological list of damaging floods that have recently occurred on Beaver Brook: November 1927; March 1936; September 1938; September 1944; November 1947; September 1955; October 1959; and April 1960.

c. Flood Profiles

High-water profiles in the lower end of Beaver Brook were determined from field data following the floods of March 1936, September 1938, and April 1960 and are shown on Plate B-5. The high water of May 1960 was approximately bank-full capacity.

6. ANALYSIS OF FLOODS

a. Available Data

In addition to the U. S. Geological Survey gaging stations noted in paragraph 4, data on recent floods on the Ashuelot River was available from staff gages at Swanzey and West Swanzey and a non-recording Telemark gage near the mouth of the Branch. These gages have been installed by the Corps of Engineers for use in the operation of the existing Surry Mountain and Otter Brook Flood Control Dams.

In order to more accurately determine the source of flows discharging into the Keene Flood Plain and also their effect on river stages in the area, a system of 5 temporary recording river gages has been established at selected locations. However, since they were installed in October 1962, no significant discharges have occurred that could be analyzed profitably.

b. Analysis

From previous studies for the existing flood control reservoirs, it has been determined that the lower portion of Beaver Brook is in the flood plain of the Ashuelot River. This flood plain is a large storage reach with its outflow at the dam in West Swanzey. Analysis of the data from the Telemark gage indicates that, under normal Ashuelot River flows, Beaver Brook stages are related to the discharge in Beaver Brook. With increased flow in the Ashuelot River, the storage reach begins to fill, and the rising Telemark stages begin to show the effect of backwater. These higher stages begin to back up the lower end of Beaver Brook. The Beaver Brook stages are now a combination of Ashuelot River stages and Beaver Brook discharges. As indicated by the flood profile on Plate B-5, the effect of the Ashuelot River backwater in a major flood can extend up Beaver Brook to the vicinity of Roxbury Street.

In the reaches above Roxbury Street, the elevation and gradient of the streambed are such that for all ranges of flow, the stages are a function only of Beaver Brook discharges.

During the September 1938 flood, it is estimated that 360 acres of residential and industrial properties along the brook were inundated up to depths of five feet. In the recent April 1960 flood, about 60 acres were affected.

c. Discharge Rating Curves

In order to determine economic benefits along Beaver Brook, it was divided into 6 damage zones (Zones I-VI), each with a respective discharge rating curve.

In the lower areas (Zones I, II, III), rating curves that represent parameters of flow on Beaver Brook versus Ashuelot River conditions, were developed and are shown on the upper portion of Plate B-6.

The discharges on Beaver Brook were determined from drainage area relationships with flows on Otter Brook and South Branch, while the stages on the Ashuelot River were based on steady-flow conditions related to the peak discharges at West Swanzey.

d. Flood Frequencies

For use in the economic analysis, discharge-frequency curves were developed for the Ashuelot River at West Swanzey and for Beaver Brook in accordance with procedures published in ER 1110-2-1450, "Hydrologic Frequency Estimates", dated 10 October 1962. The method considers that the logarithmic value of annual peak flows are normally distributed, thereby permitting the application of standard statistical analysis. This enables the discharge-frequency curve to be defined by its mean value and standard deviations. Statistical analysis of flood flows in New England have indicated that the data had a positive skewness.

The discharge frequency curve for the Ashuelot River at West Swanzey was developed from a correlation with the statistical analysis of the U. S. G. S. gaging station at Hinsdale wherein a skew coefficient of 1.0 was used. This resulted in the flood of record, (September 1938), having an annual chance of occurrence of 1.25 percent, or an average recurrence interval of 80 years.

The discharge-frequency curve for Beaver Brook was derived from correlations with gaging station records from the South Branch and Otter Brook. Both of these stations also had discharge-frequency curves with skew coefficients of 1.0. The statistical analysis resulted in the September 1938 flood of record on Beaver Brook having an annual chance of occurrence of about 0.75 percent or average recurrence interval of 133 years.

As noted previously, the flood stages in the lower portion of Beaver Brook are a function of coincident flow from Beaver Brook and backwater from the Ashuelot River. Therefore, a typical or average stage-frequency curve was required for economic analysis in the lower reaches. The most likely coincident conditions of flow are also indicated on the plot of stage-discharge relationships shown in the upper portion of Plate B-6. These curves were derived from the correlation of flows for each selected frequency. This was considered to be reasonable since the flood histories of the streams are similar.

The water surface elevations under the most likely coincident flow conditions are shown as natural stage-frequency curves on the lower portion of Plate B-6. Under the assumed conditions, the experienced 1938 flood elevations in the lower reaches of Beaver Brook have an average recurrence interval of about 60 years. The derivations of the modified stage-frequency curves shown on Plate B-6 are discussed in Paragraph 13 of this appendix.

7. EXISTING FLOOD CONTROL PROJECTS IN THE ASHUELOT RIVER WATERSHED

a. Surry Mountain Dam

The dam, which was completed in 1942, is located in the Town of Surry on the Ashuelot River about 6 miles upstream of the Faulkner and Colony Dam. It controls a drainage area of 100 square miles, with the reservoir containing a flood control storage equivalent to 5.9 inches of runoff.

b. Otter Brook Dam

The dam, which was completed in 1958, is in the City of Keene on Otter Brook about 5 miles upstream of the confluence of The Branch and the Ashuelot River. It controls a drainage area of 47 square miles with the reservoir containing a flood control storage equivalent to 7.0 inches of runoff.

c. Ashuelot River Channel Improvement

In 1954, the Corps of Engineers improved the channel of the Ashuelot River in Keene by means of a clearing and snagging project which increased allowable discharge rates from Surry Mountain Dam.

d. Ash Swamp Brook Watershed Plan

In 1961, the Soil Conservation Service administered land treatment measures and channel improvements on Ash Swamp Brook. However, as there were no provisions for the impoundment of flows on this stream, these improvements had no effect on the regulation procedures of the reservoirs.

8. AUTHORIZED FLOOD CONTROL PROJECTS

Honey Hill dam was authorized in August 1941, but is presently in an inactive status. The dam would be located in the Town of Swanzey on the South Branch approximately 5.5 miles upstream of the confluence with the Ashuelot River. It would control an area of 70 square miles with the reservoir containing flood control storage equivalent to 7.0 inches of runoff.

9. RECOMMENDED FLOOD CONTROL PROJECTS

a. General

Methods of solving the flood problems in Keene resulting from recurring high water on Beaver Brook were studied and included the following: channel improvements, diversion and relocation of Beaver Brook, flood plain zoning, evacuation and resettlement, channel improvements along the Ashuelot River, and modification of the dam at West Swanzey. A discussion of these alternatives can be found in paragraph 42 of the main report.

Construction of a dam and reservoir on Beaver Brook was found to be the most practical solution to the flood problems along Beaver Brook.

b. Beaver Brook Dam and Reservoir

The Beaver Brook damsite is located on Beaver Brook in the City of Keene, about four miles upstream of its mouth and will control a drainage area of 5.98 square miles. The reservoir will be multi-purpose with the storage used for flood control, recreation, and if desired by local interests at a later date, for water supply. Plate B-7 shows the area-capacity relationships of the proposed reservoir.

1. Flood Control Storage. - The reservoir will provide a flood control storage of 2,750 acre-feet, equivalent to 8.62 inches of runoff.

2. Recreation - Water Supply Storage. - Upon completion of the project, a pool with an area of 203 acres and storage of 3,000 acre-feet will be maintained for recreational purposes. At a future date when local water supply needs increase, this storage capacity may be used for water supply purposes. The amount of storage prescribed was determined by a consulting firm for the City of Keene after a thorough study of the present water supply system, projected growth, and future water supply requirements. From a preliminary review of nearby discharge records, it has been estimated that the 3,000 acre-feet of storage will provide a safe yield

of 4.0 m.g.d. The following table contains pertinent data on the proposed reservoir.

TABLE B-9

PERTINENT DATA

	Elevation feet, msl	Water Area Acres	Capacity Acre-Feet	Capacity Inches
River Bed at Site	773	-	-	-
Recreation Pool Storage	811	203	3,000	9.40
Flood Control Storage	-	-	2,750	8.62
Spillway Crest	822		5,750	18.02

1" Runoff = 319 acre-feet

10. SPILLWAY DESIGN FLOOD

a. General

The spillway design flood represents the runoff that would result from the probable maximum precipitation falling on ground saturated from previous rains. Concurrently, it is assumed that the reservoir initially is filled to spillway crest as a result of previous storms. Discharge through the ungated conduit is relatively small, hence was neglected during routing computations to determine the spillway design discharge.

b. Probable Maximum Precipitation

Values of rainfall for the spillway design flood were obtained from Hydrometeorological Report No. 33, dated April 1965, as prepared by the U. S. Weather Bureau. The values were modified according to design criteria discussed in OCE letter dated 10 April 1964 concerning the Hop Brook Hydrology Design Memorandum. The selected rainfall is about 80 percent of the all season average probable maximum precipitation for 10 square miles. The distribution of the rainfall excess in shown in Table B-10. It was assumed that the most intense 6-hour rainfall was divided in two 3-hour amounts, with 67 percent in one 3-hour period and 33 percent in the other 3-hour period. Rainfall intensity during the two 3-hour periods of the maximum 6-hour total were assumed as uniform. Losses from infiltration and surface detention were assumed at a rate of 0.15 inches per 3 hours, which is consistent with minimum losses determined in previous studies for the New England area.

TABLE B-10

PROBABLE MAXIMUM PRECIPITATION

Time (Hours)	Maximum Precipitation (Inches)	Losses (Inches)	Rainfall Excess (Inches)	Rainfall Pattern (Inches)
0	-	-	-	-
3	11.85	0.15	11.70	0.45
6	5.85	0.15	5.70	0.45
9	1.05	0.15	0.90	0.90
12	1.05	0.15	0.90	5.70
15	0.60	0.15	0.45	11.70
18	0.30	0.15	0.45	0.90
21	0.30	0.15	0.45	0.45
24	0.30	0.15	0.45	0.45
	21.3	1.20	20.1	20.1

c. Unit Hydrograph

The adopted three-hour unit hydrograph was determined from analysis of streamflow records in the Ashuelot River watershed, along with unit hydrographs for other small comparable drainage areas with similar runoff characteristics. The peak discharge of the adopted unit hydrograph for the spillway design flood is 700 cfs, which is equivalent to 117 csm. Plate No. B-8 compares the two-hour and three-hour unit hydrograph adopted for the spillway design flood with the two-hour unit hydrograph adopted for the standard project flood.

d. Spillway Design Flood

The spillway design flood inflow for Beaver Brook Reservoir was developed from the probable maximum precipitation and the adopted unit hydrograph. The peak inflow of the spillway design flood is 10,000 cfs, equivalent to about 1,670 csm. Assuming the reservoir initially full to spillway crest from previous floods and disregarding the relatively small flow through the outlet, the flood was routed through the reservoir. (see Plate B-9). Standard ogee weirs, with lengths from 50 to 125 feet, were used in the routing of the design flood. A 100-foot spillway was adopted as the most economical. Because of the significant surcharge storage, the resulting discharge peak was reduced to 6,000 cfs, with a resulting surcharge of 6.3 feet. The top of dam was established at elevation 833 msl, providing 4.7 feet of freeboard.

11. OUTLET WORKS

a. General

The outlet for Beaver Brook Dam will consist of a concrete conduit, approximately 5' x 5', with discharge controlled by an entrance sluice gate locked in a partially open position. For purposes of flood control operation, this arrangement is comparable to an ungated and unattended detention structure. The size and capacity of the conduit will be adequate (1) to pass the normal flow of the stream without using more than a minor portion of the flood control storage; (2) to reduce flood flows so that the conduit discharge will not seriously affect Beaver Brook stages in downtown areas of Keene; (3) to permit evacuation of the reservoir within a reasonable time after a flood; (4) to pass a flood of reasonable size during construction without requiring a cofferdam of excessive height; (5) to inspect and maintain the conduit. A general plan with profiles and sections of the outlet is shown on Plate C-2.

b. Water Supply

A small conduit will be incorporated in the larger concrete conduit and will carry future water needs through the dam.

12. STANDARD PROJECT FLOOD

a. General

A standard project flood on Beaver Brook was developed (1) to show the effectiveness of the proposed reservoir, and (2) as a basis for the design of alternative methods of flood control, such as channel improvement, flood walls, diversion, etc.

b. Standard Project Storm

The standard project flood developed for the Beaver Brook watershed is based on standard project storm rainfall as described in Civil Engineer Bulletin No. 52-8 (dated 26 March 1952). A tabulation of 2-hour rainfall and rainfall excess is shown in Table B-11 on the following page.

c. Unit Hydrograph

The two-unit hydrograph adopted for the standard project flood inflow is about 85 percent of the comparable two-hour unit hydrograph used in developing the spillway design flood. It has a peak value of 725 cfs, which is equivalent to 121 csm (see Plate B-8).

TABLE B-11

STANDARD PROJECT STORM RAINFALL

Time (Hours)	2-Hour Rainfall (Inches)	Losses (Inches)	Rainfall Excess (Inches)
0	-	-	-
2	5.4	0.15	5.25
4	1.5	0.15	1.35
6	0.9	0.15	0.75
8	0.6	0.15	0.45
10	0.4	0.15	0.25
12	0.4	0.15	0.25
14	0.3	0.15	0.15
16	0.3	0.15	0.15
18	0.2	0.15	0.05
20	0.2	0.15	0.05
22	0.1	0.10	-
24	0.1	0.10	-
TOTAL	10.4	1.70	8.7

d. Standard Project Flood

The peak inflow of the standard project flood, as developed from the unit hydrograph and the standard project storm rainfall, is 4,500 cfs, equivalent to 750 csm.

13. EFFECT OF RESERVOIR REGULATION

a. General

Since the sluice gate in the flood control outlet will be pre-set and locked, the reservoir will act as an automatic detention basin. The reservoir will be regulated to provide a high degree of protection from all floods on Beaver Brook from the damsite downstream to the vicinity of Roxbury Street. Further downstream on Beaver Brook, discharges will be reduced from 75% to 60%. The effect of these discharge reductions on water surface elevations varies with Ashuelot River stages. The effect of the reservoir on the Ashuelot River and Connecticut River is small and was considered proportional to reductions provided by Otter Brook Reservoir on a drainage area relationship.

Plate B-5 shows the effect of the reservoir on the April 1960 high water profile in the lower reaches of Beaver Brook.

Routings of the record flood of September 1938 and the Standard Project Flood indicated the storage capacity in the reservoir will be adequate. Plate B-10 shows the effect of the reservoir on these two floods.

b. Reductions

The determination of average reductions as measured by a typical flood was required for the derivation of annual benefits to the project. The proposed dam and reservoir will reduce peak discharges about 60 percent in the lower reaches of Beaver Brook. To obtain the modified stages in the reaches affected by backwater from the Ashuelot River, it was also necessary to determine average reductions on the main river. However, in the determination of the benefits attributed to the Beaver Brook project, the reductions were taken last in a series of reservoirs which included Surry Mt., Otter Brook, and the authorized Honey Hill project. The systems were analyzed and the resultant peak discharge percent reduction of a typical flood are shown in the following tabulation.

TABLE B-12

PERCENT REDUCTIONS OF NATURAL PEAK FLOWS
ASHUELOT RIVER AT WEST SWANZEY

Reservoir Systems	Reductions in Percent
Existing Surry Mt. and Otter Brook	40
Surry Mt., Otter Brook, and Beaver Brook	42
Surry Mt., Otter Brook, and Honey Hill (auth.)	59
Surry Mt., Otter Brook, Honey Hill and Beaver Brook	60.4

The above percentages were used to modify the flows for selected frequencies on the Ashuelot River as assumed for the coincident natural conditions. The modified discharges were combined with the modified flows on Beaver Brook and applied to the stage-discharge relationship indicated on the upper section of Plate B-6. The resultant elevations were used to plot the modified stage-frequency relationships indicated on the lower sections of Plate B-5. The effect of Beaver Brook on the Connecticut River was computed assuming it was the last added in a system of 17 reservoirs. Incremental reductions assigned to Beaver Brook were small and were considered proportional to reductions provided by Otter Brook Reservoir on a drainage-area relationship.

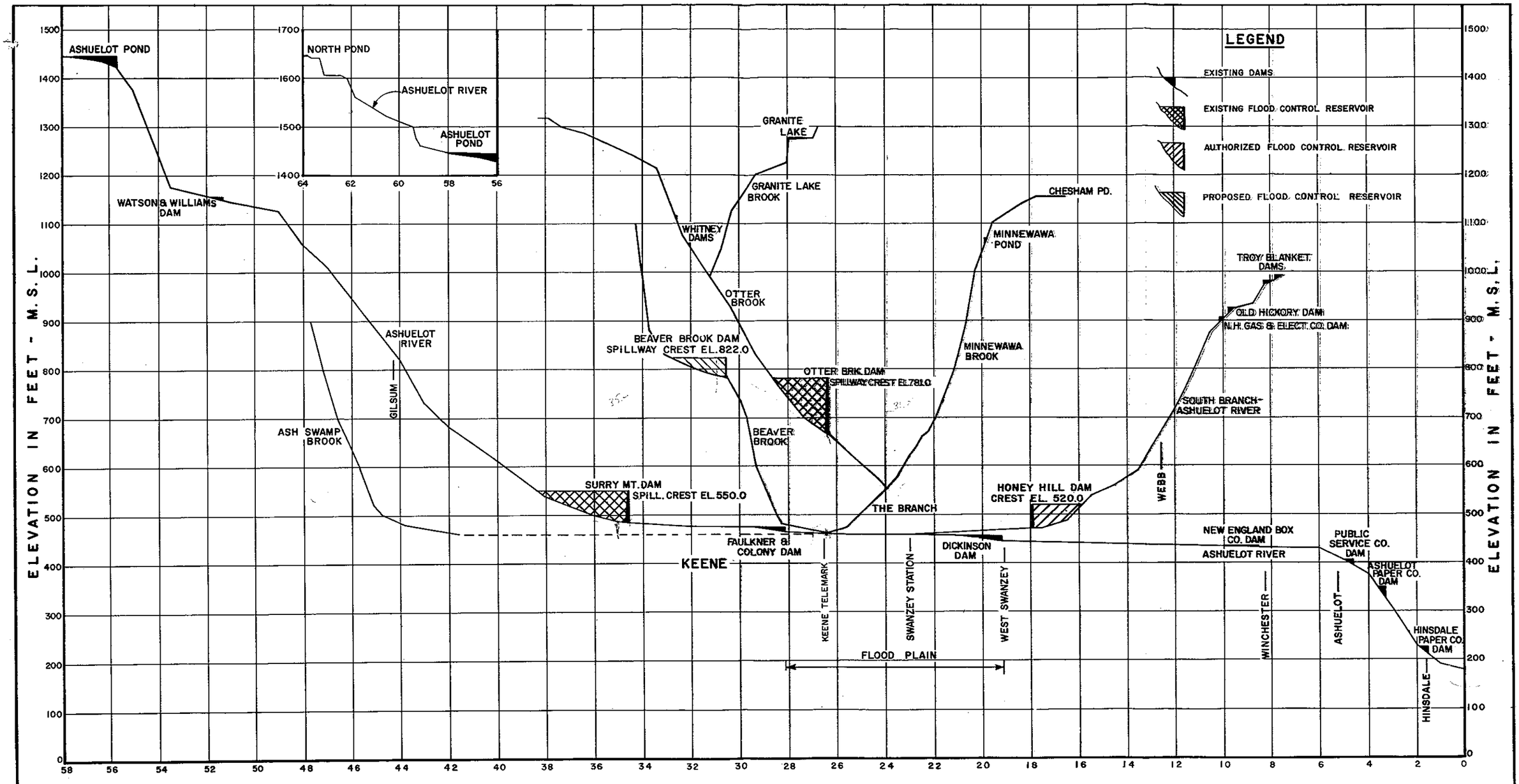
14. HYDROLOGIC EQUIPMENT

a. Pool Recorder

In accordance with EM 1110-2-3600, Reservoir Regulation, a pool stage recorder will be installed at Beaver Brook Dam. In the absence of a gate tower and float well, a bubble gage similar to the type developed by the U. S. Geological Survey will be installed.

b. Radio Gage

Releases from Surry Mountain and Otter Brook Reservoirs will be coordinated with the outflows from the unattended Beaver Brook Dam. Since the dam will be unattended, a battery-operated radio transmitter will be installed which will send "on command" pool stages to both Reservoir Regulation Section and the operator at Surry Mountain Dam. This arrangement will provide a reliable means of gathering this data, especially during severe storms when normal facilities frequently are disrupted.



CONNECTICUT RIVER FLOOD CONTROL

ASHUELOT RIVER BASIN PROFILES

ASHUELOT RIVER AND TRIBUTARIES

NEW ENGLAND DIVISION WALTHAM, MASS.

NOVEMBER 1966

PLATE NO. B-1

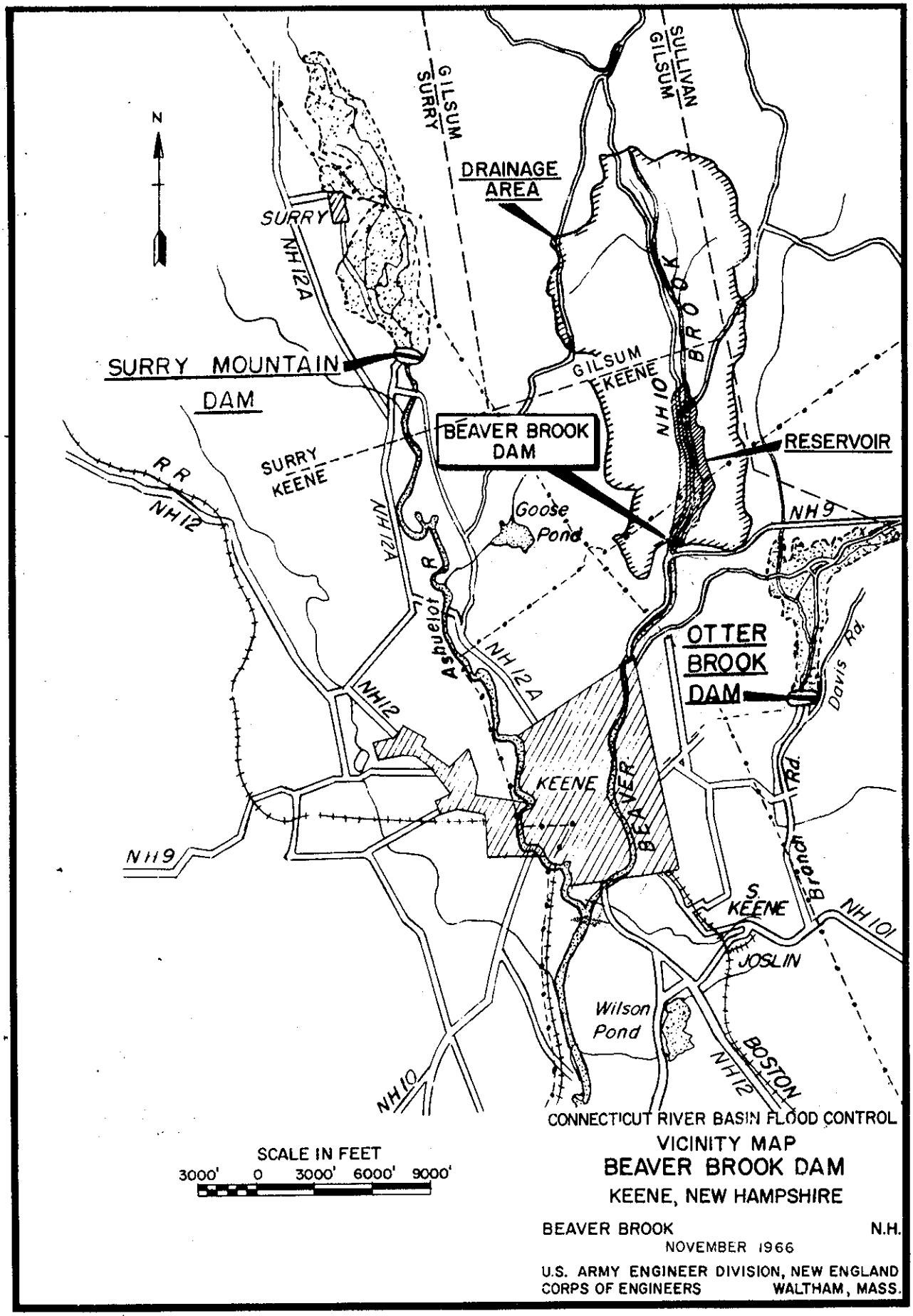
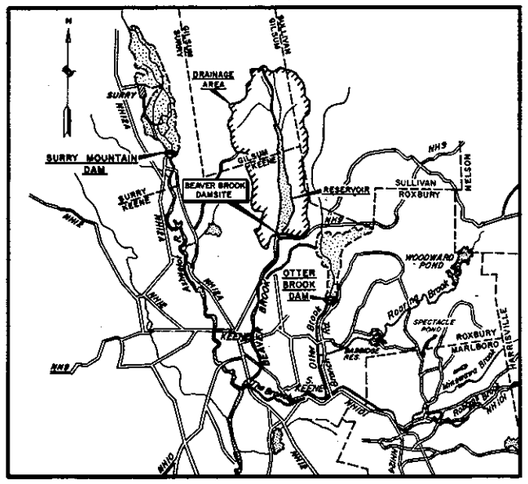

N
GILSUM
SURRY
SULLIVAN
GILSUM
DRAINAGE
AREA
SURRY
NH12A
SURRY MOUNTAIN
DAM
GILSUM
KEENE
BEAVER BROOK
DAM
NH10
BROOK
RESERVOIR
SURRY
KEENE
R R
NH12
NH12A
Goose
Pond
NH9
Ashuelot R
NH12A
OTTER
BROOK
DAM
Davis Rd.
NH12
KEENE
BEAVER
TRR
Branch
N119
S
KEENE
NH101
JOSLIN
Wilson
Pond
BOSTON
NH12
NH10
SCALE IN FEET
3000' 0 3000' 6000' 9000'
CONNECTICUT RIVER BASIN FLOOD CONTROL
VICINITY MAP
BEAVER BROOK DAM
KEENE, NEW HAMPSHIRE
BEAVER BROOK N.H.
NOVEMBER 1966
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS WALTHAM, MASS.

PLATE B-2

CORPS OF ENGINEERS

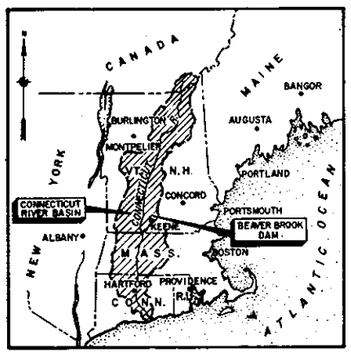
U.S. ARMY



VICINITY MAP

SCALE IN FEET

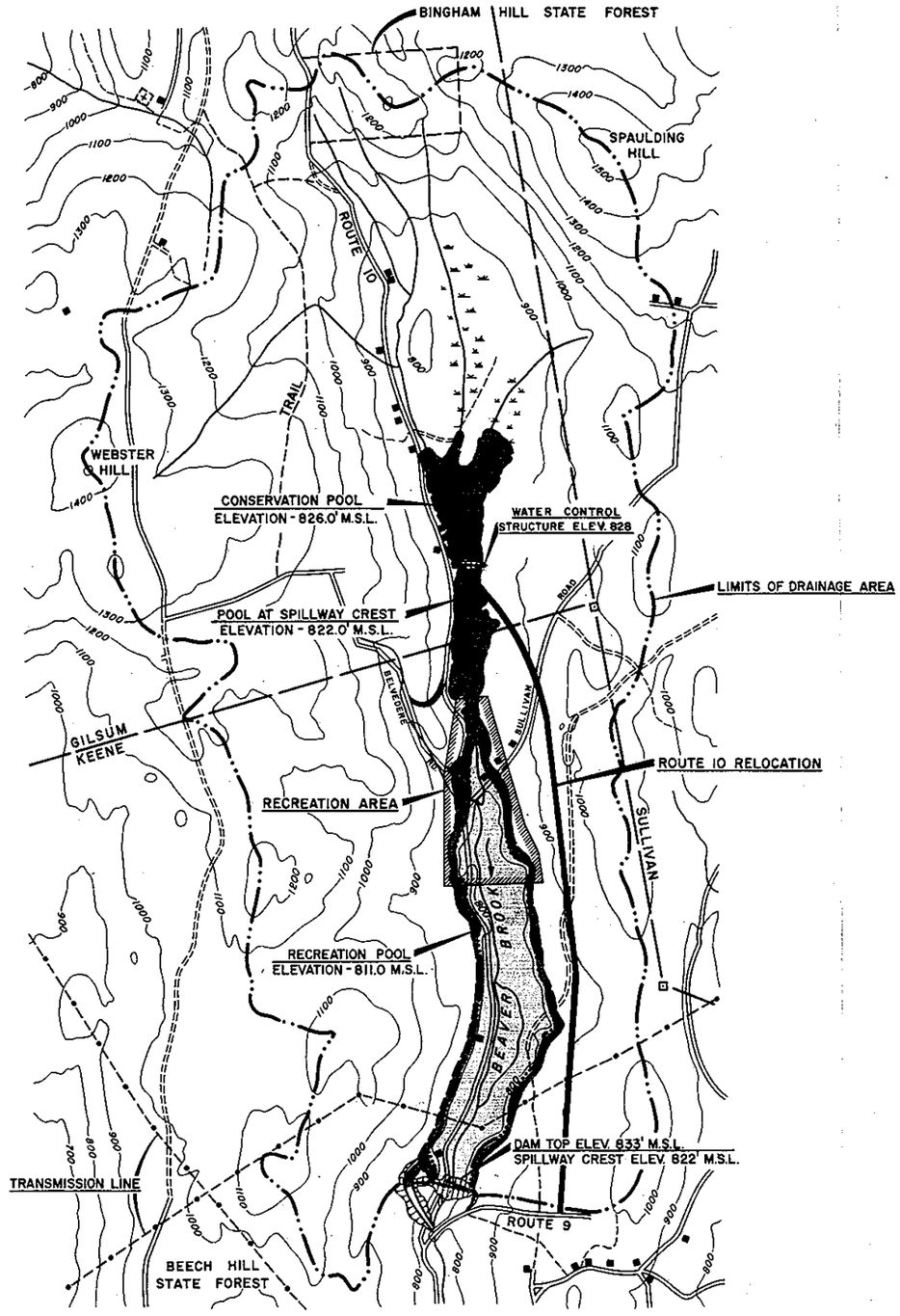
3000' 0 3000' 6000' 9000'



LOCATION MAP

SCALE IN MILES

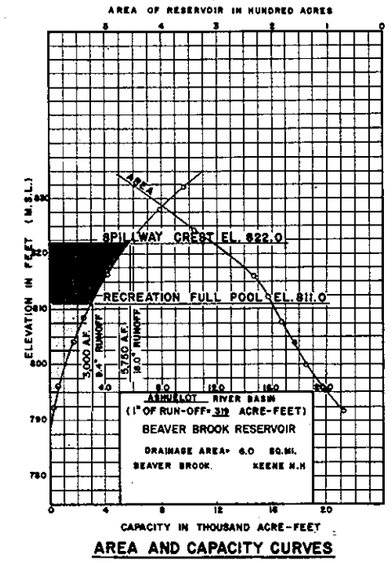
40 0 40 80



RESERVOIR PLAN

SCALE IN FEET

1,000 0 1,000 2,000



AREA AND CAPACITY CURVES

NOTE:

Route 10 in reservoir area to be relocated.
115 KV Transmission line to be relocated (6,000 L.F.).
Elevations refer to Mean Sea Level Datum.
Topography is based on Nov.-Dec. 1964 and Jan. 1965 survey by U.S. Army Corps of Engineers.

REVISION	DATE	DESCRIPTION	BY
A	3-6-67	Reservoir Plan and Vicinity Map Revised	

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY F.W.S. | DR. BY M.S. | CK. BY

PROJECT ENGINEER

CHIEF, DESIGN BRANCH | CHIEF, PROJECTS BRANCH | CHIEF, P & R BRANCH

CONNECTICUT RIVER FLOOD CONTROL
KEENE, NEW HAMPSHIRE

BEAVER BROOK DAM
DRAINAGE AREA AND RESERVOIR PLAN
BEAVER BROOK, NEW HAMPSHIRE

APPROVED

CHIEF, ENGINEERING DIVISION

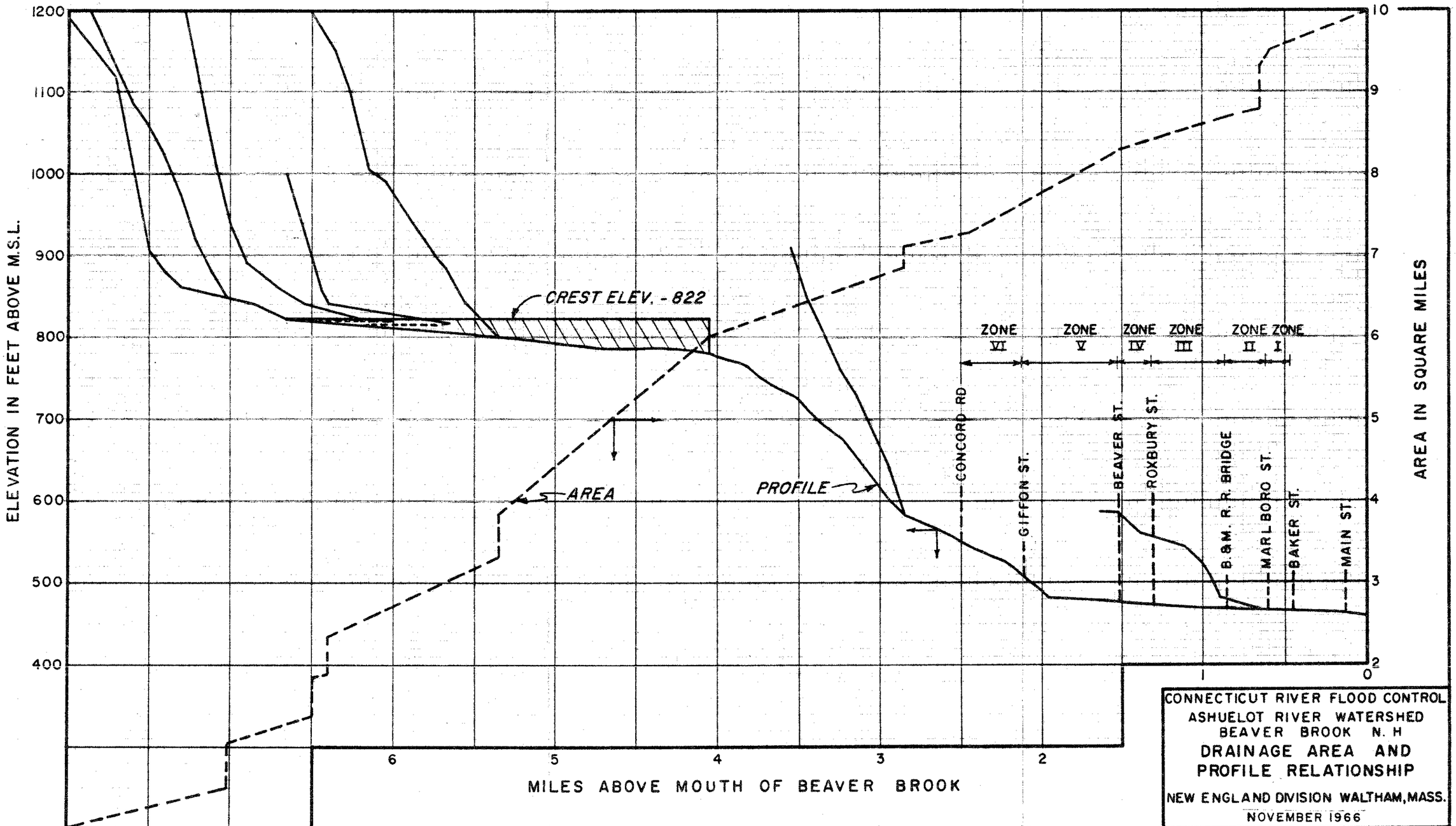
DATE NOV. 1966

TO ACCOMPANY REPORT
DATED: NOVEMBER 1966

SCALE: AS SHOWN

DRAWING NUMBER

PLATE NO. B-3



CONNECTICUT RIVER FLOOD CONTROL
ASHUELOT RIVER WATERSHED
BEAVER BROOK N. H
DRAINAGE AREA AND
PROFILE RELATIONSHIP
NEW ENGLAND DIVISION WALTHAM, MASS.
NOVEMBER 1966

PLATE NO. B-4

ZONE IV — ZONE III — ZONE II — ZONE I

NOTES:

1.) The experienced Sept. 1938 and March 1936 floods without the effect of any reservoirs.

2.) The April 1960 flood was modified by Surry Mt. and Otter Brook Reservoirs.

SEPT. 1938 FLOOD Q=2,200 c.f.s. ±

MARCH 1936 FLOOD Q=900 c.f.s. ±

APRIL 1960 FLOOD MODIFIED BY BEAVER BROOK DAM

APRIL 1960 FLOOD Q=600 c.f.s. ±

MAY 1960 HIGH WATER Q=120 c.f.s. ±

PROFILE OF STREAMBED

THE BRANCH

ELEVATION IN FEET — M. S. L.

484
480
476
472
468
464
460
456

BEAVER ST. | SPRING ST. | ROXBURY ST. | CHURCH ST. | HARRISON ST. | WATER ST. | R.R. BRIDGE | MYRTLE ST. | MARLBORO ST. | BAKER ST. | MAIN ST.

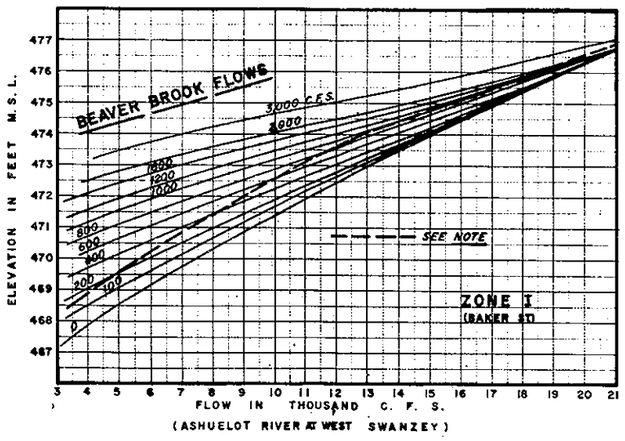
8000 7600 7200 6800 6400 6000 5600 5200 4800 4400 4000 3600 3200 2800 2400 2000 1600 1200 800 400 0

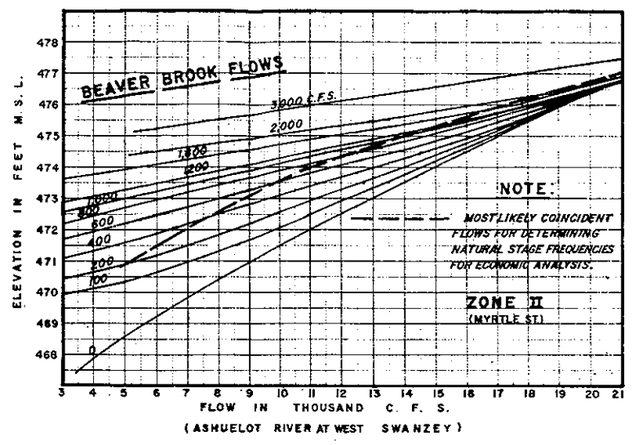
DISTANCE IN FEET ABOVE MOUTH OF BEAVER BROOK

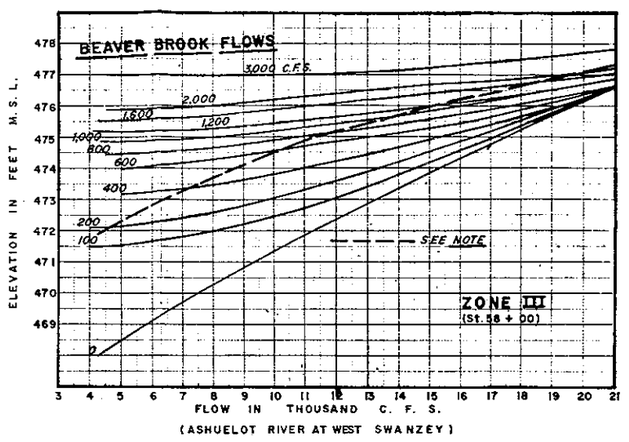
CONNECTICUT RIVER FLOOD CONTROL
ASHUELOT RIVER WATERSHED
HIGH WATER PROFILES FOR ZONES I-IV ON BEAVER BRK.
NEW ENGLAND DIVISION WALTHAM, MASS.
NOVEMBER 1966

PLATE NO. B-5

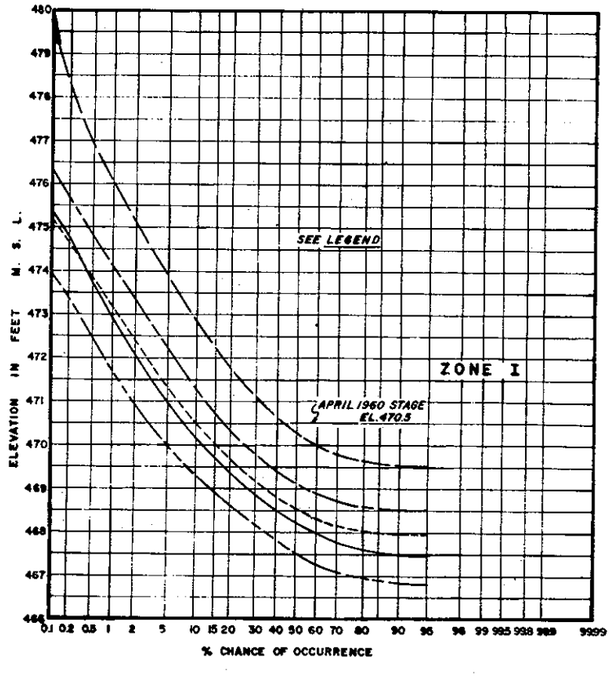
DISCHARGE RATING CURVES

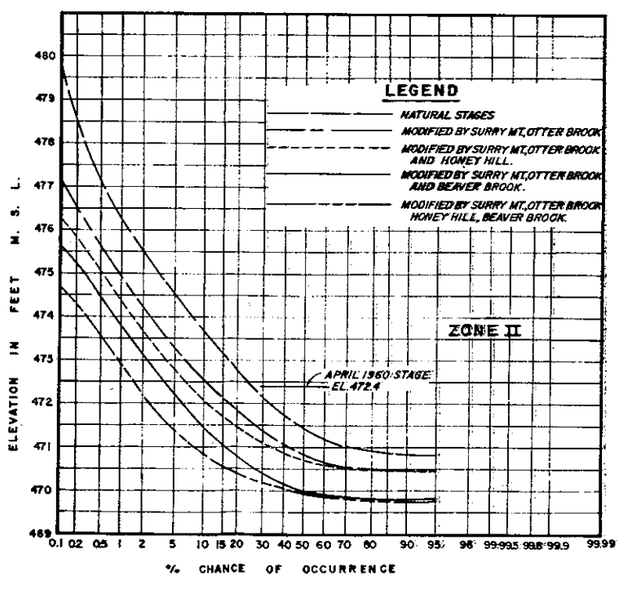


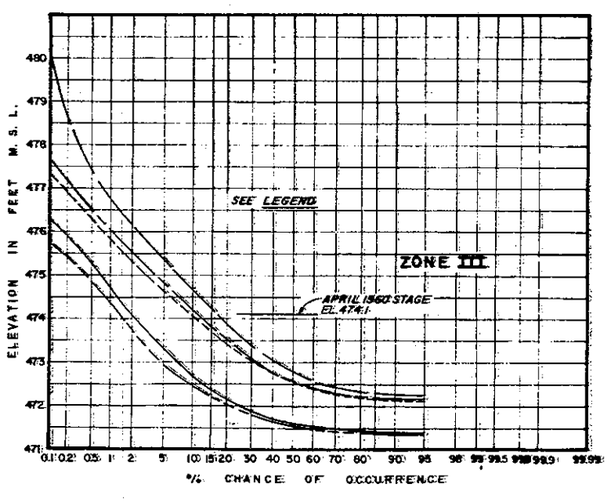




STAGE-FREQUENCY CURVES







CONNECTICUT RIVER FLOOD CONTROL

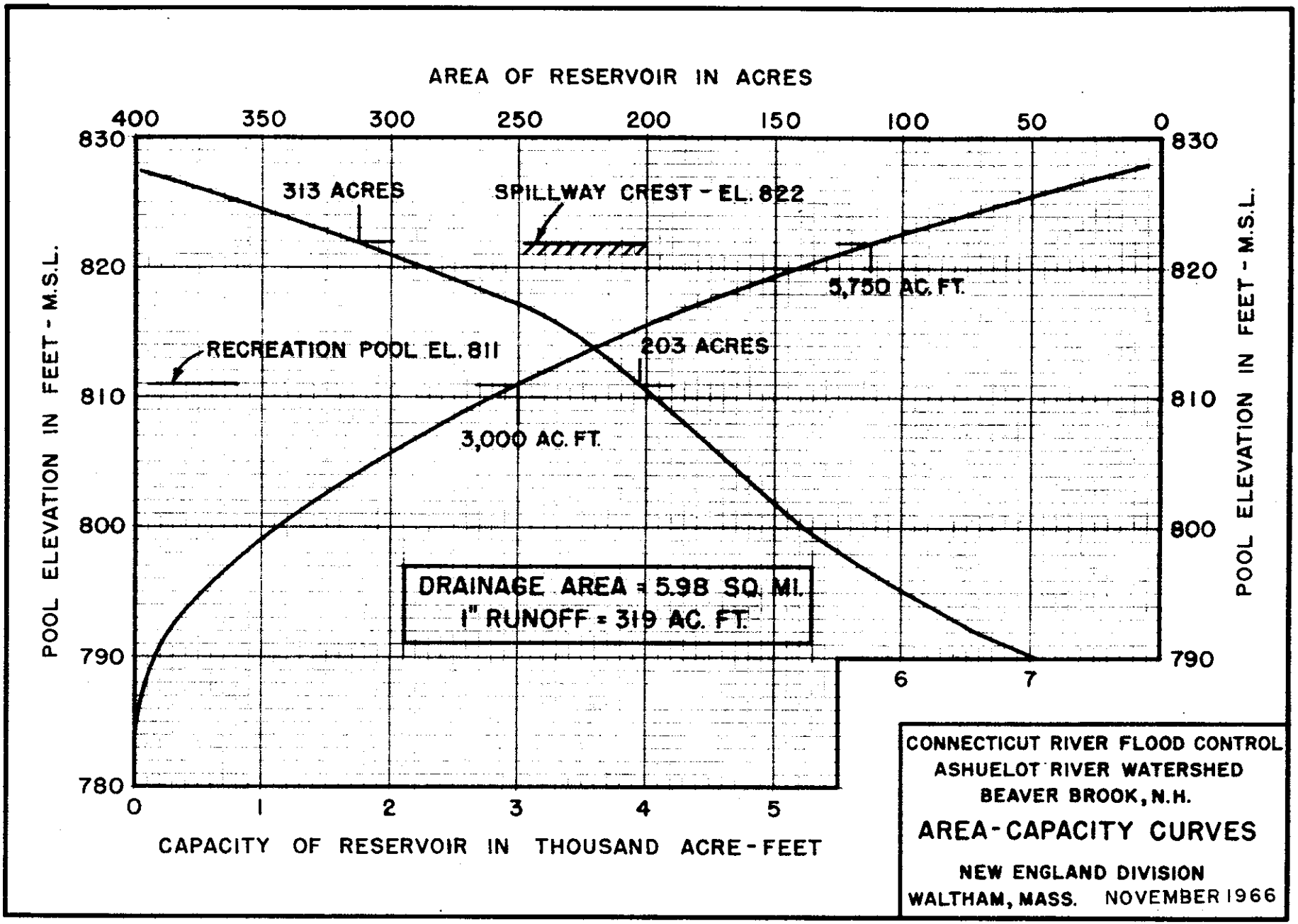
ASHUELOT RIVER WATERSHED

DISCHARGE RATING & STAGE FREQUENCY CURVES FOR ZONES I, II, III, ON BEAVER BROOK

U.S. Army Engineer Division, New England
Corps of Engineers Waltham, Mass.

NOVEMBER 1966

PLATE NO. B-6

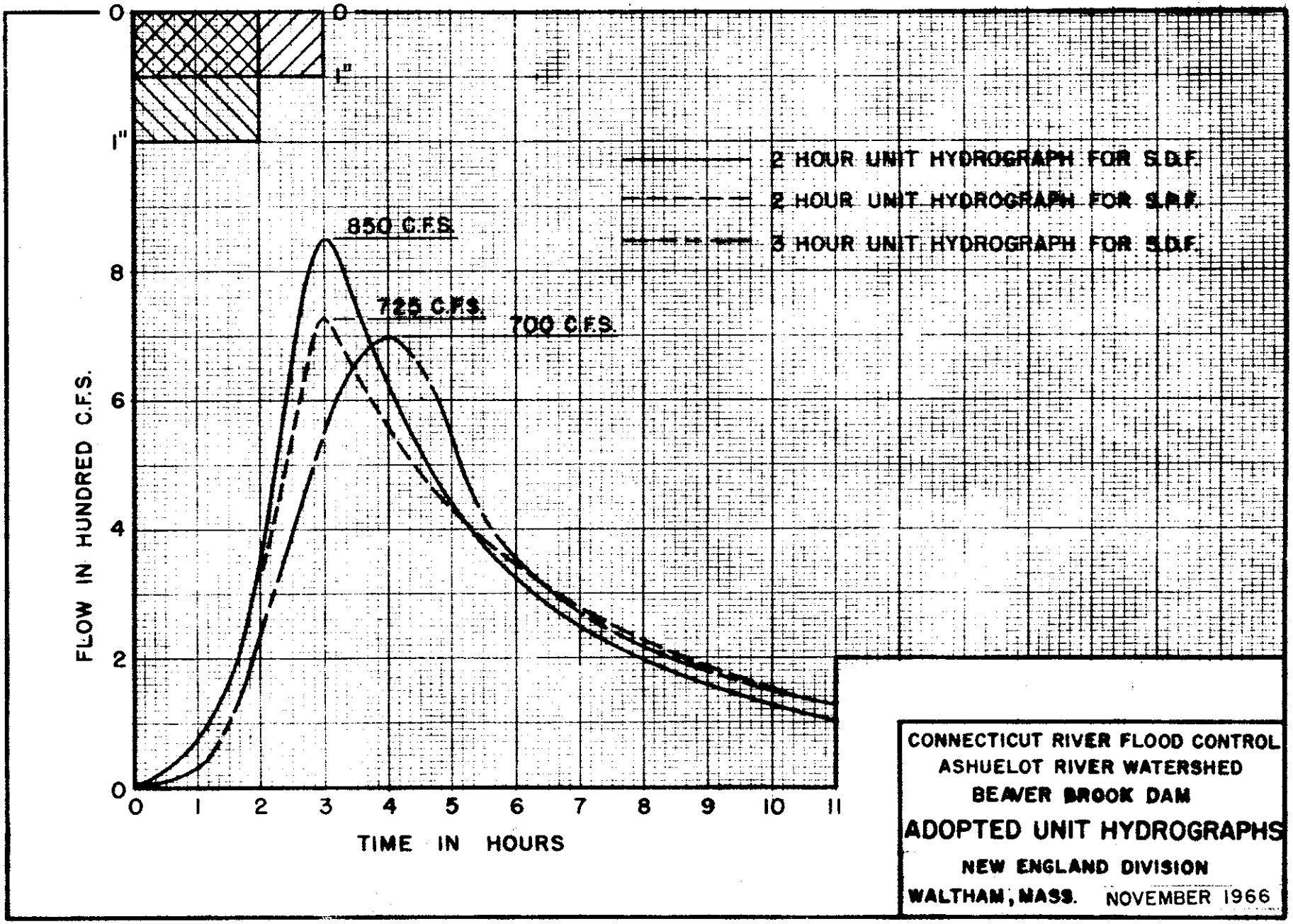


CONNECTICUT RIVER FLOOD CONTROL
ASHUELOT RIVER WATERSHED
BEAVER BROOK, N.H.

AREA-CAPACITY CURVES

NEW ENGLAND DIVISION
WALTHAM, MASS. NOVEMBER 1966

PLATE NO. B-7



CONNECTICUT RIVER FLOOD CONTROL
ASHUELOT RIVER WATERSHED
BEAVER BROOK DAM
ADOPTED UNIT HYDROGRAPHS
NEW ENGLAND DIVISION
WALTHAM, MASS. NOVEMBER 1966

PLATE NO. B-8

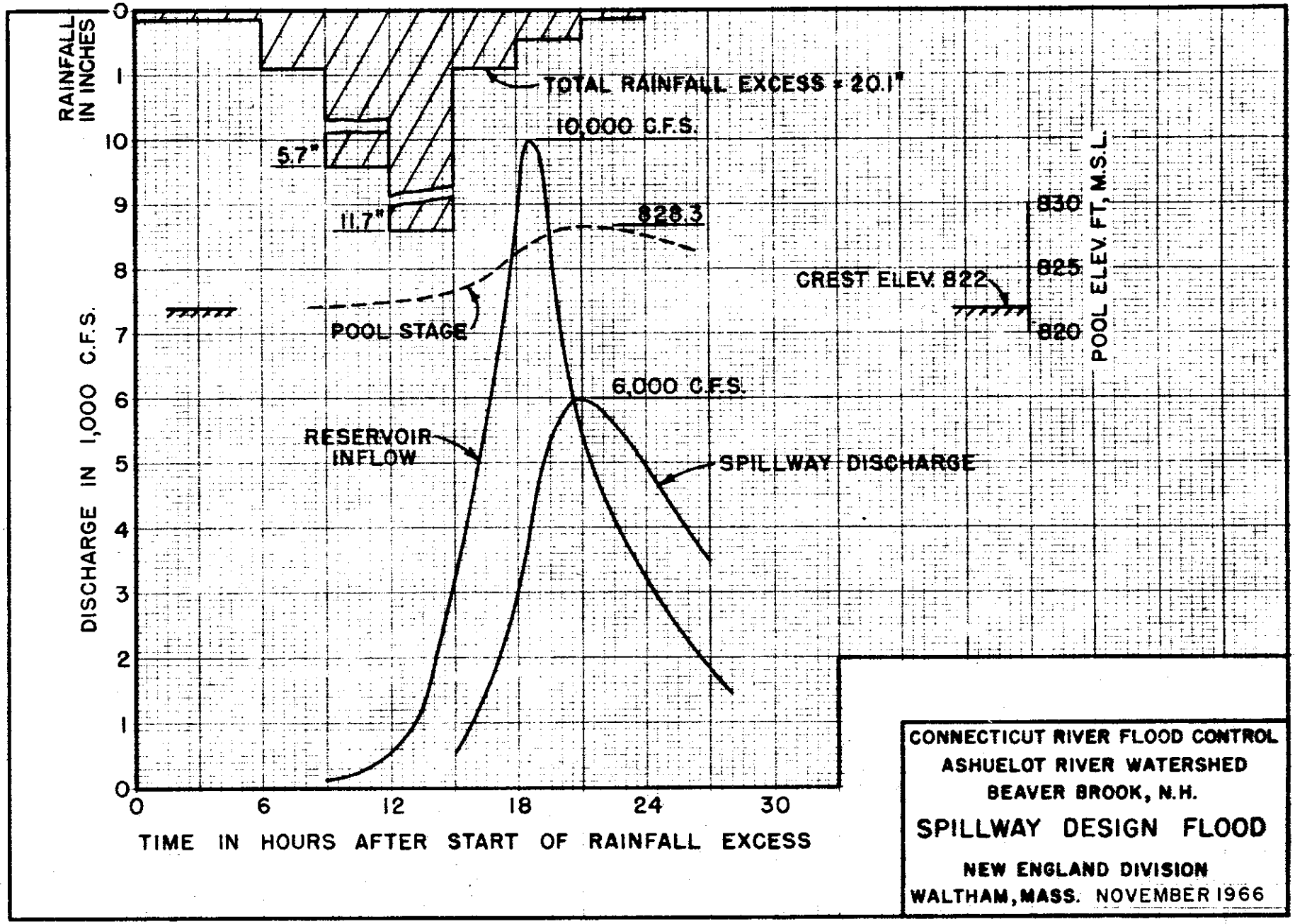
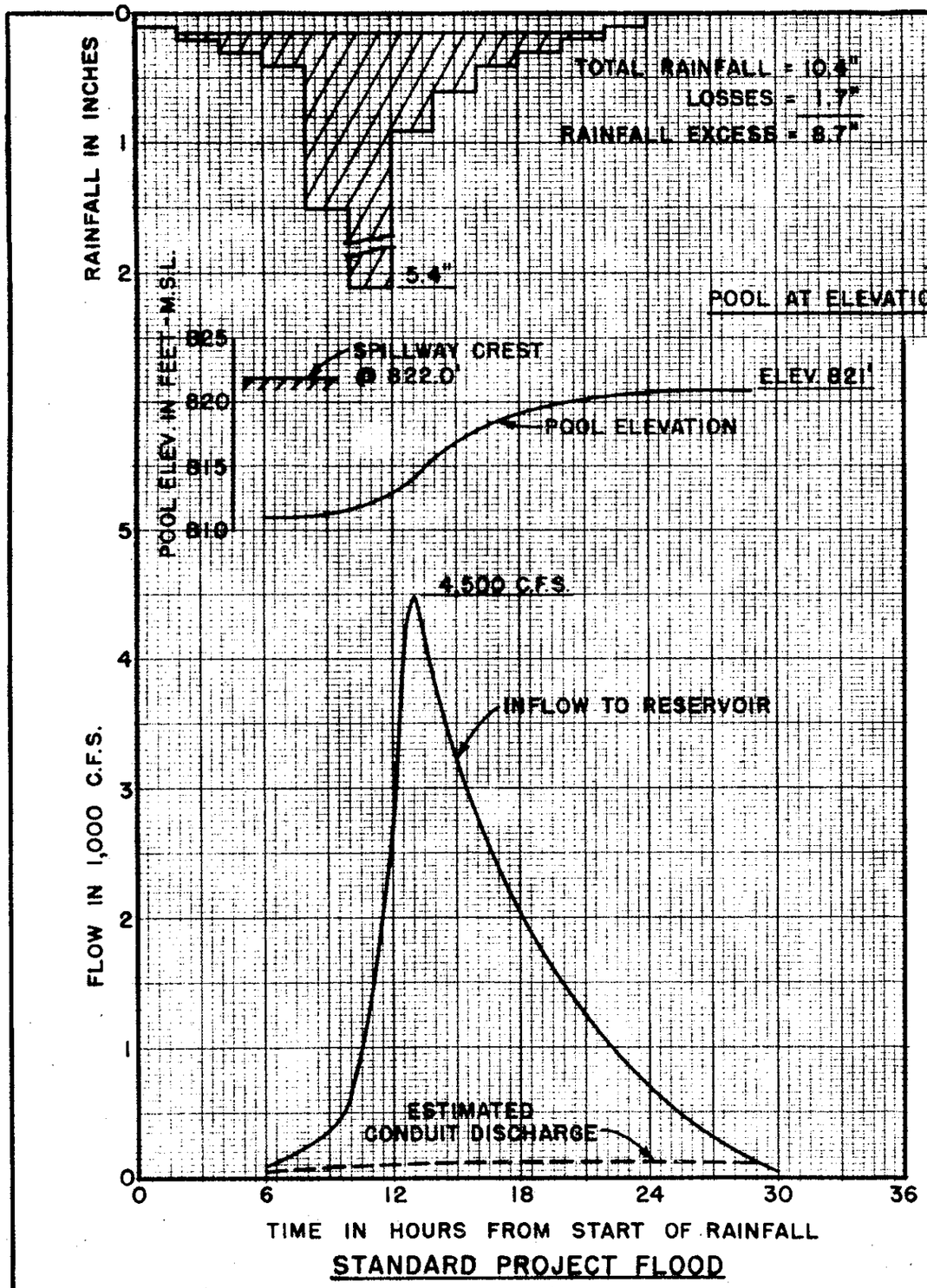
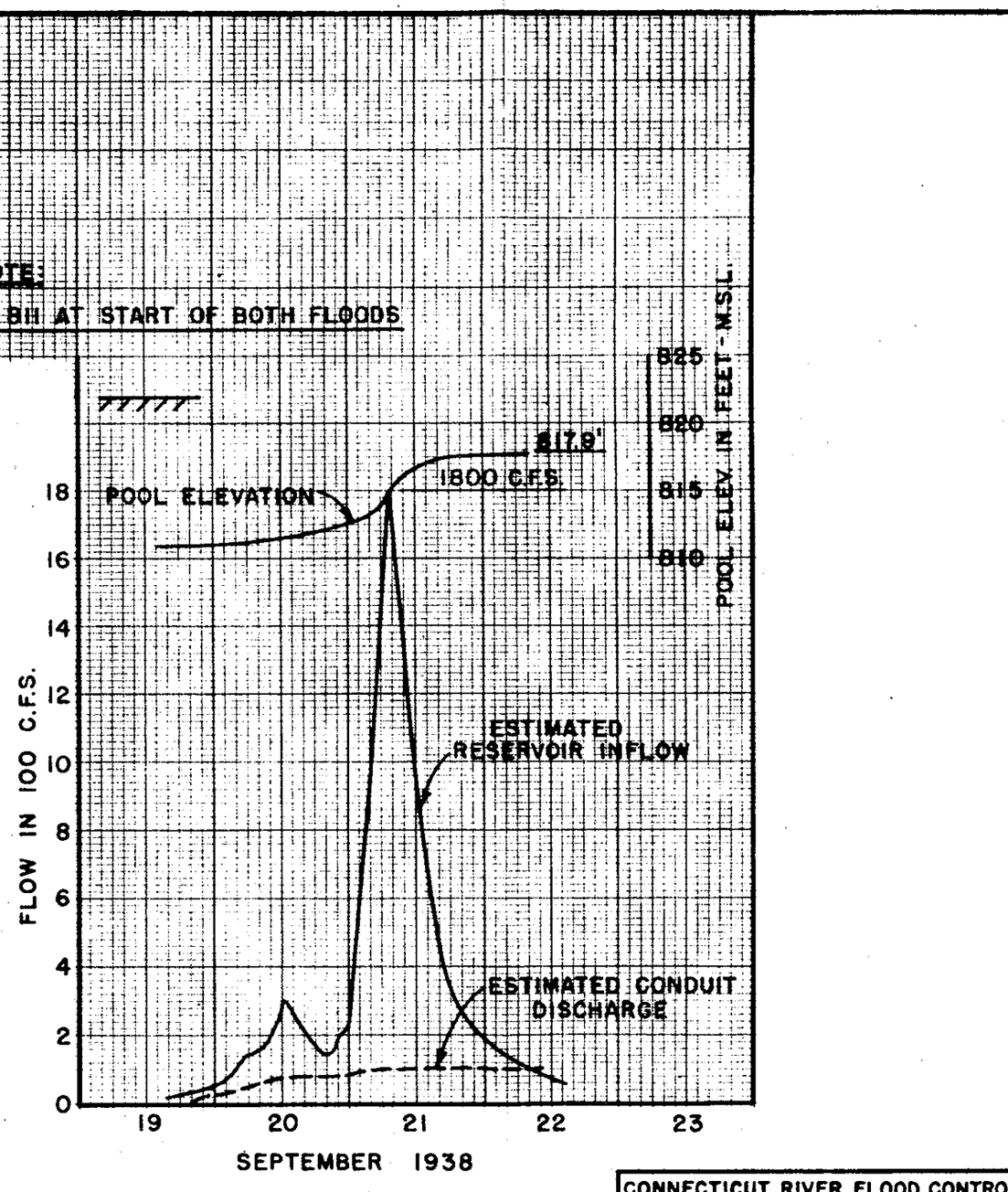

RAINFALL IN INCHES
DISCHARGE IN 1,000 C.F.S.
TOTAL RAINFALL EXCESS = 20.1"
10,000 C.F.S.
5.7"
11.7"
828.3
POOL STAGE
CREST ELEV. 822
6,000 C.F.S.
RESERVOIR INFLOW
SPILLWAY DISCHARGE
POOL ELEV. FT, M.S.L.
830
825
820
0
1
2
3
4
5
6
7
8
9
10
0
6
12
18
24
30
TIME IN HOURS AFTER START OF RAINFALL EXCESS
CONNECTICUT RIVER FLOOD CONTROL
ASHUELOT RIVER WATERSHED
BEAVER BROOK, N.H.
SPILLWAY DESIGN FLOOD
NEW ENGLAND DIVISION
WALTHAM, MASS. NOVEMBER 1966

PLATE NO. B-9



STANDARD PROJECT FLOOD



CONNECTICUT RIVER FLOOD CONTROL
ASHUELOT RIVER WATERSHED
BEAVER BROOK, N.H.

STANDARD PROJECT FLOOD
& SEPTEMBER 1938 FLOOD

NEW ENGLAND DIVISION
WALTHAM, MASS. NOVEMBER 1966

PLATE NO. B-10

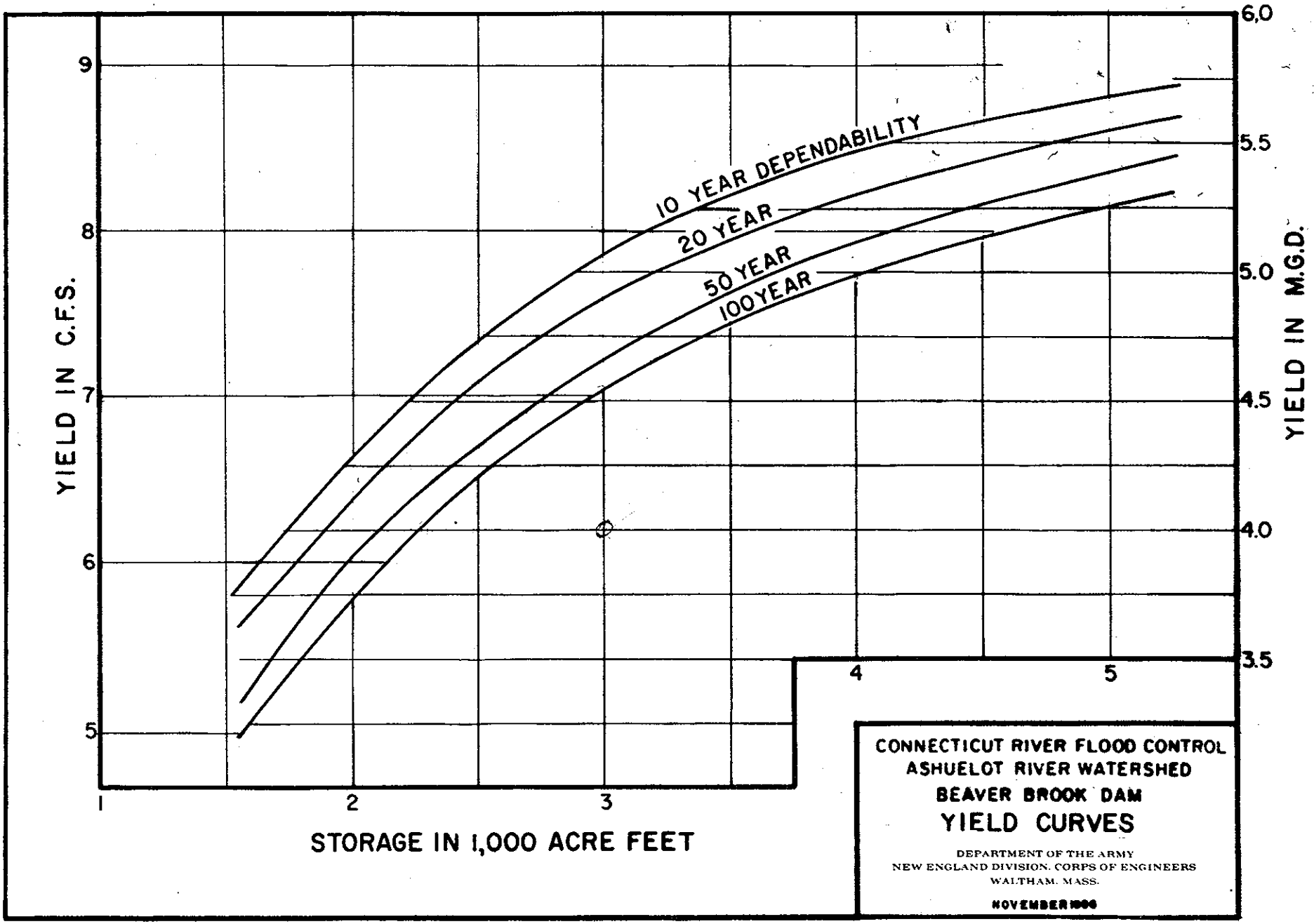

YIELD IN C.F.S.
9
8
7
6
5
1
2
3
STORAGE IN 1,000 ACRE FEET
10 YEAR DEPENDABILITY
20 YEAR
50 YEAR
100 YEAR
4
5
6.0
5.5
5.0
4.5
4.0
3.5
YIELD IN M.G.D.
CONNECTICUT RIVER FLOOD CONTROL
ASHUELOT RIVER WATERSHED
BEAVER BROOK DAM
YIELD CURVES
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.
NOVEMBER 1966

PLATE NO. B-11

APPENDIX C

PROJECT DESCRIPTION AND COSTS

APPENDIX C

PROJECT DESCRIPTION AND COSTS

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APPENDIX C

PROJECT DESCRIPTION AND COSTS

1. PROJECT DESCRIPTION

a. General. The recommended multiple-purpose dam and reservoir would include flood control, a permanent recreation pool, fish and wildlife conservation, and future water supply. The principal construction features will consist of a dam and reservoir, a concrete chute-type spillway, gated but uncontrolled outlet works, relocation of State Highway Route 10 and a water supply conduit for future use. In addition, a water control structure will be located in the upper reaches of the reservoir in order to mitigate losses to waterfowl caused by inundation of an existing 25-acre wetland habitat. Pertinent data for the recommended plan is shown in Table No. C-1.

b. Reservoir. The dam and reservoir provides control for a drainage area of six square miles. The reservoir at spillway crest elevation 822 m.s.l. would have a total storage capacity of 5,750 acre-feet and would be about 2.5 miles long with a surface area of approximately 310 acres. A permanent pool for recreation and future water supply maintained at elevation 811 feet, m.s.l. would have a surface area of 203 acres and a storage capacity of 3,000 acre-feet, equivalent to 9.4 inches of runoff. The remaining 2,750 acre-feet or 8.6 inches of runoff would be reserved for flood control. The limits of the reservoir as well as the drainage area are shown on Plate No. C-1.

c. Dam and Spillway. The Beaver Brook dam site is located about 2.5 miles north of the center of Keene, New Hampshire, and 1,100 feet upstream from where State Highway Route 9 crosses Beaver Brook. The dam would be constructed of compacted earth fills with rock slope protection on upstream and downstream slopes and would be approximately 950 feet long, 60 feet high at the stream bed, with a top elevation of 833 feet, mean sea level. The top of dam to be 20 feet wide would afford a 16-foot roadway to the spillway from the access road. A chute-type spillway with a concrete ogee weir 100 feet in length at crest elevation 822 feet, m.s.l., would be constructed on rock in the west abutment of the dam. The spillway is capable of passing a peak discharge of 6,000 cubic feet per second with a surcharge of 6.3 feet and 4.7 feet of freeboard between maximum water level and the top of dam. A plan view and section of the dam is shown on Plate No. C-2.

d. Outlet Works. The outlet works would consist of a cast-in-place rectangular concrete conduit 5 feet wide by 5 feet high, gated but with a fixed control at the intake structure. The size and capacity of the concrete box conduit will be adequate to use for diversion of the stream during construction, and to pass a flood of reasonable size during construction. A 5' x 5' gate is provided forward of the box conduit. This gate will be set to control discharges downstream during flood periods. An overflow weir with stoplogs would be provided at the intake structure to maintain the permanent recreation pool at elevation 811 feet, mean sea level. A gated 24-inch pipe with a box inlet upstream of the intake structure will act as a low flow outlet and draw-down. A section of the outlet works and conduit is shown on Plate No. C-2.

e. Water Supply. Provisions for future water supply include dual-level, gate-valved intake pipes which would connect inside the intake structure to the water supply line provided in the conduit outlet. The 24" water supply line would be plugged until such time as the city desires to convert the recreation pool to water supply use. Sections of the pipeline are shown on Plate No. C-2.

f. Relocations. Construction of the project requires the relocation of about 2.6 miles of Route 10 presently located in the reservoir area, as well as a new intersection with Sullivan Road. A section of Belvedere Road will be relocated to provide access to farms west of the reservoir from the existing Route 10. Utilities, consisting of telephone and 2400-volt electric power lines along Route 10 and Sullivan Road would also be relocated. In addition, a 115 KV transmission line which crosses the reservoir area about 1,200 feet upstream of the dam will be relocated south of the dam site. The approximate location of the relocated Route 10 is shown on Plate No. C-1.

g. Water Control Structure. A water control structure located about 2.2 miles north of the dam is provided to compensate for the loss of an existing waterfowl refuge which will be inundated by the reservoir. The structure would create a pool with a surface area of approximately 50 acres at elevation 826 feet, mean sea level, and impound about 175 acre-feet of storage. The pool would be controlled by an overflow box inlet structure and a 36-inch bituminous coated corrugated metal pipe outlet to pass normal flows. An 80 foot grass spillway set at elevation 826.5 feet, mean sea level, will be located along the left bank of the structure to handle flood flows. The impoundment would be constructed of rolled earth fill with a grassed top and side slopes. The structure which lies

well upstream of the main dam, and relocated Route 10, has been designed in accordance with EM 1110-2-1101. The structure is considered expendable in the event of a rare flood since it's failure will effect no loss of life, or property. It would be approximately 430 feet long, 11 feet high at the stream bed, and have a top width of 20 feet at elevation 828 feet, mean sea level datum. The side slopes will be 1 vertical on 3 horizontal for the upstream slope, and 1 vertical on 2.5 horizontal for the downstream side.

h. Recreation. Land and water areas in and adjacent to the reservoir will be allocated to recreational activities and fish and wildlife conservation. Initial facilities contemplated include swimming, picnicking, boating, fishing, and other water-oriented uses. General recreation is discussed in Appendix E.

i. Real Estate. The land and improvements to be acquired in fee for all water resource project purposes, estimated at 730 acres, consists of an area bounded by the flood control pool at maximum surcharge elevation 828 mean sea level. Areas required for the construction of the dam and appurtenant structures, the work and borrow areas, and the relocation of Route 10 are also included. Details and estimates of real estate costs are included in Appendix D.

TABLE NO. C-1

PERTINENT DATA

BEAVER BROOK DAM AND RESERVOIR

Drainage Area	6 square miles
Dam	
Type	Rolled earth fill with rock slope protection
Top elevation	833 feet, m.s.l.
Top width	20 feet
Maximum height	60 feet
Length	950 feet
Upstream slope	1 vertical on 3 horizontal
Downstream slope	1 vertical on 2.5 horizontal
Spillway	
Type	Concrete ogee weir
Peak design flood inflow	10,000 c.f.s.
Peak design flood outflow	6,000 c.f.s.
Crest elevation	822 feet, m.s.l.
Crest length	100 feet
Surcharge	6.3 feet
Freeboard	4.7 feet
Outlet Works and Intake Structure	
Outlet conduit	Gated 5' x 5' concrete box
Intake structure	15' x 15' x 45' high concrete structure with overflow weir
Low-flow outlet	24" R.C. Pipe
Water supply line	24" R.C. Pipe (two level intake)
Sluice gates	5' x 5' and 2' x 2'
Water supply gate valves	2 - 24"
Storage Capacities	
Recreation and water supply	3,000 acre-feet
Flood control	2,750 acre-feet
Total	5,750 acre-feet

TABLE NO. C-1 (Cont'd)

Water Surface Elevations and Areas

Recreation and water supply pool	Elev. 811 - 203 acres
Flood control	Elev. 822 - 310 acres
Maximum surcharge	Elev. 828.3 - 410 acres

Stream Flow at Dam Site

Maximum recorded discharge	1,800 c.f.s.
Average discharge	9 c.f.s.
Storm of April 1960	400 c.f.s.
Storm of September 1938	1,800 c.f.s.

Upstream Water Control Structure

Type	Rolled earth fill with grassed top and slopes
Top elevation	828 feet, m.s.l.
Water surface elevation & area	826 feet, m.s.l. - 50 acres
Top width	20 feet
Maximum height	11 feet
Length	430 feet
Upstream slope	1 vertical on 3 horizontal
Downstream slope	1 vertical on 2.5 horizontal
Storage capacity	175 acre-feet
Overflow and outlet works	Overflow box inlet structure and 36-inch BCCM pipe
Grass Spillway (left bank)	80 feet, 826.5 feet, m.s.l.

Construction Period

Beaver Brook Project	2 years

2. GEOLOGY

a. General. The valley of Beaver Brook is physiographically located within the New England Upland in a maturely dissected region of moderately high relief. Glaciation has modified the pre-glacial bedrock topography by erosion and more so by dumped and outwashed deposition of glacial debris from moving and stagnant ice masses. Glacial till, a heterogeneous product of direct deposition, generally blankets the bedrock surface and occasionally in the area has been molded into low hill features known as drumlins. The east-west valley of the Ashuelot River to the north was dammed by glacial till masses creating a temporary glacial lake which may have spilled over the present divide into the north-south valley of Beaver Brook. The till in the lower sides of the valley of Beaver Brook is overlain by remnants of gravelly terraces which were built by melt water streams flowing beside tongues of ice.

The bedrocks of the region are principally Devonian in age and largely consist of granite and gneiss. Mica schist of the Littleton Formation narrowly fingers between these rocks along the valley of Beaver Brook and this zone of rock contacts may account for a largely structural origin of the valley.

Bodies of pegmatite, very coarse grained granite containing large to giant size crystals of feldspar and often rich in beryl and sheet mica, frequently occur intrusive in the country rocks of this area. There are numerous mines in the pegmatites, but there are no known operations or prospects that would be affected by the construction of the reservoir.

b. Foundations and Materials Investigations. Subsurface explorations to determine foundation conditions, in general, have consisted of 35 test borings continuously drive-sampled in overburden to recover 2-1/2-inch diameter samples and core-drilled into bedrock where encountered a minimum penetration of 20 feet for recovery of NX (2-1/8-inch) diameter cores. Other subsurface exploration was made by trenching the overburden face of the existing highway cut on the near right abutment. The layout of explorations is shown on Plate No. C-3 together with a geologic-log section along the centerline of dam.

Subsurface explorations made for borrow sources of natural materials for construction of dam embankment have consisted of test borings and trenches. Random and impervious materials will be available from required excavations and from an area on the left abutment immediately upstream of the embankment. Investigation for

sources of pervious materials within the reservoir and beyond has been accomplished by geologic reconnaissance.

c. Site Geology. The highway at the site cuts the near right abutment just above the brook valley exposing up to about 20 feet of glacial till or till-like material. The topography beyond the top of highway cut is knobby but, in general, is terrace-like for a distance of about 500 feet westerly where elevation is attained on the main wall of the valley for tie of embankment. Bedrock is not exposed on the right abutment within limits of the siting, but is indicated at very shallow depth by a knob of detached blocks about 350 feet north or upstream of the spillway. Glacial till (compact, silty or clayey, gravelly sand) directly overlies the rock surface except for evidences of localized water-laid deposition in the far right abutment area in the vicinity of the spillway. The knobbly surface of the right abutment appears to represent superficial dumping of glacial debris consisting of mixed materials, partly reworked and sorted and containing numerous scattered and nested boulders and surface blocks up to 30 cubic yards in size.

The overburden of the stream section and left abutment is glacial till at or very near the ground surface. Boulders are prevalent, but size and concentrations do not compare with the superficial condition on the right abutment. Bedrock (schist) outcrops in the stream bed about 200 feet downstream of the centerline of dam at the remains of an old stone dam and about 500 feet upstream on the left bank of the brook. The orientation of the schist foliation is essentially that of the trend of the brook valley. These outcrops and intervening borings along the conduit alignments show the rock surface to be at no greater depth than about 20 feet in the stream section throughout this reach.

d. Foundation Conditions. The compact, impervious nature of the glacial till and its prevalent occurrence near ground surface accessibly provides firm foundation for embankment and conduit and a material to which cutoff can accessibly be made for control of under-seepage under the main embankment. The intake control tower will be founded in the schist bedrock.

Available geologic mapping indicates the schist bedrock to underlie the right abutment. However, explorations in the spillway area within their depth penetrations have encountered only pegmatite (very coarse-grained granite). The pegmatite, as indicated by recoveries and condition of core samples, should provide firm and

tight foundation for the weir structure with little or no preparatory excavation or grouting. The excavation for spillway discharge channel will be bottomed and partially sided in rock for varying but generally shallow depths for some distance beyond the toe of embankment.

e. Reservoir Leakage. There are no low divides on the limits of the reservoir that require diking. The sides and extremity of the reservoir rise mountainously above maximum flood pool and are faced by exposed bedrock or glacial till over the rock. Cutoff to impervious glacial till will be made under the dam embankment in its major sections.

f. Construction Materials. Compacted fills of impervious and random type materials constitute the bulk of dam embankment. These materials are available as glacial till, upper weathered till or till-like materials and other near surface materials. Excavations for spillway approach and discharge channels will provide some of the required natural materials and the major portion of impervious material will be handily borrowed from the left abutment area just upstream of the dam.

Pervious fill material is required for drainage zones in the dam embankment. Sand and gravels principally occur in the valley of Beaver Brook as terrace remnants on the lower right wall. These deposits have largely been depleted for highway construction, but portions are preserved a short distance upstream of the damsite under the present highway which will be relocated. Similar deposits occur in the extremity of the reservoir about three miles north and potential major sources are located in the Ashuelot Valley to the north at a haul distance of about six miles.

Rock for embankment fill and slope protection will be partially provided from excavation for the spillway discharge channel. Relatively shallow excavation will be involved for the most part and with consideration to occurrence of weathered surfaces and pockets, some areas will produce little suitable rock. Subsurface explorations indicate that pegmatite will predominate and, although a competent rock insitu, its large crystal structure and particularly heavy micaceous zones will tend to easy breakdown from blasting and during handling and placement. It, therefore, may be necessary to go to borrow for rock suitable as upstream slope protection. Some suitable rock may be selectively obtained from required excavation and by breaking of boulders and blocks encountered in stripping and overburden excavation. Excavations for relocation of the highway may provide surplus rock

that could be selectively stockpiled for use. There are no active or abandoned stone quarries in the area. Excellent quality rock (gneiss removed in rehabilitation of the spillway for Surry Mountain Dam is spoiled in great quantity in that reservoir about four miles airline distance northwest of the Beaver Brook site. The spoil pile is roughly graded and covered with sandfill and the minimum haul route of about eight miles requires travel through the northern section of the City of Keene. Rock partly exposed in old borrow pits in the terrace remnants upstream of the dam could be further economically exposed for quarrying by borrowing of remaining pervious materials.

Processed materials for gravel bedding and concrete aggregates are available from commercial plants located in Keene and in Walpole, New Hampshire, at a maximum haul distance of about 20 miles. Aggregates from both sources have been tested and used in civil works construction. In connection with concrete materials, there are four commercial sources of processed sand and gravel within a twenty-five (25) mile haul distance of the project site. Of these sources, three have been previously tested and approved for Civil Works construction. A reinvestigation of the previously approved sources to determine their status and plant prices and complete investigation of additional potential sources of concrete aggregate will be performed during the design studies of the project.

3. EMBANKMENT AND FOUNDATIONS

a. General. Design and engineering studies have been made to the extent considered necessary for this report relative to the foundation, embankment and earthwork. A program of investigations consisting of subsurface explorations, field reconnaissance and laboratory investigations, including shear tests, has been made to determine: (1) the characteristics of the foundation soils for the proposed embankment; (2) the characteristics and extent of the materials to be excavated; and (3) the characteristics and availability of a potential source of borrow material. The location of the subsurface explorations performed are shown on Plate No. C-3. The site geology of the area is described in paragraph 2 of this appendix.

b. Characteristics of Foundation Soils. The overburden with the embankment foundation area consists generally of a gray, compact to very compact glacial till deposit which, in the valley bottom and on the right abutment, is capped by variable sands and gravels. Within a limited reach of the right abutment, however,

the glacial till deposit is discontinuous and the variable sands and gravels overlie the bedrock directly. Although there is a pocket as deep as 25 feet in the valley, the thickness of the overburden in the valley and at lower elevations on the left abutment is generally less than 10 feet. However, at higher elevations on the left abutment, the thickness is in excess of 25 feet. The thickness of the overburden on the right abutment ranges from about 3 feet near the extreme right limit of the abutment to a thickness in excess of 35 feet in the major portion of the abutment. There are a substantial number of large surface boulders on the right abutment and scattered surface boulders and cobbles occur throughout the remainder of the area but are more concentrated in the valley bottom. The overburden contains cobbles and boulders and is generally covered by about one foot of topsoil except in the valley, where topsoil and minor organic deposits may occur to depths of up to 3 feet.

The materials in the glacial till deposit have gravel contents of less than 20 percent and fine contents ranging from 35 to 55 percent of the component passing the No. 4 Sieve. The materials are generally slightly plastic having liquid limits ranging from 21 to 24 and plastic limits of from 14 to 18. The variable sands and gravels which cap the glacial till or bedrock directly, vary in thickness from about 7 feet in the valley section into a maximum of about 17 feet on portions of the right abutment. This capping, consisting of gravelly silty sands and silty sands and gravels, has gravel contents of from 0 to 50 percent and fine contents of from 10 to 40 percent of the component passing the No. 4 Sieve.

With the exception of surficial materials, which will be removed, there are no soft or low shear strength materials and it is estimated that foundation materials will have shear strength parameters in excess of $\phi = 30^{\circ}$ and C = 0 TSF for all conditions.

c. Characteristics of Embankment Materials.

(1) Materials from required excavations

(a) Overburden. The materials from the required excavations which will become available for embankment construction will consist of soil from excavations for the foundation cutoff and spillway. Preliminary studies indicate that the material from these excavations will consist of variable gravelly silty sands and more uniform soil from the glacial till deposit. The variable sands occur predominantly within the approach channel of the spillway and as a capping over the glacial till deposit in

the discharge channel and right abutment areas and are similar to those encountered in the foundation area as described previously. Material in the glacial till deposit is similar to that encountered within the foundation area of the embankment as described previously.

(b) Rock. The required rock excavation from the spillway channel is expected to be suitable for rock slope protection and rock fill after processing except that it may not be suitable for rock slope protection on a portion of the upstream slope of the embankment. Current estimates indicate that the quantity of required rock excavation will not be sufficient to meet the requirements of the embankment. It is considered that the additional required rock, as necessary, might be provided by adjustments in the grades and widths of the spillway channel. If necessary, suitable rock can be obtained by quarrying in undeveloped sources in the Beaver Brook valley within a few miles of the dam site or by processing high quality stone material in a government-owned spoil pile located at a haul distance of about 8 miles.

(2) Borrow Materials

(a) General. Explorations indicate that the quantity of materials from the required earth excavations, although significant, will not be sufficient to complete the embankment. Reconnaissance and explorations made to locate a source of borrow disclosed that the glacial till deposit encountered in the embankment foundation and spillway areas extends upstream of the left abutment. Investigations determined that the bulk of the material in this area is similar to the glacial till material available from required excavations and therefore is suitable for impervious borrow.

(b) Gravel Bedding and Embankment Drainage Materials. A reconnaissance of the Beaver Brook valley has indicated that although some deposits do exist from which gravel bedding and embankment drainage materials could be obtained, none of these are capable of economical development as borrow sources. Materials suitable for use as gravel bedding and embankment drainage materials are available from commercially developed pits located within 20 miles of the site and from undeveloped sources in the Ashuelot valley within a haul distance of 6 miles.

d. Embankment Design. The design of the embankment was influenced in large measure by the quantity and the difference in characteristics between the glacial till and variable sands available from required excavations and an economical borrow source of

glacial till. On the basis of their characteristics, particularly with respect to permeability, the glacial till and variable sands will be utilized as impervious and random fill materials, respectively, in the embankment.

The selected section for the dam embankment, shown on Plate No. C-2, consists of a large zone of impervious fill with a foundation cutoff, a random fill zone, a downstream inclined drainage zone, a small downstream rock toe and upstream and downstream rock slope protection. This section was selected to utilize to the maximum extent possible, without stockpiling, the variable sands and material from the glacial till deposit available from required excavations and to minimize the use of more costly borrow materials. Detailed estimates of materials to be obtained from required excavations may necessitate some revisions to the internal zoning of the embankment during final design. From laboratory investigations and preliminary studies, it is considered that a downstream slope of 1 on 2.5 and an upstream slope of 1 on 3 (with a service road berm) will provide a stable embankment under all conditions of reservoir operation. The selected slopes, however, are considered tentative pending final design studies. Seepage through the embankment will be controlled by the arrangement of the random and impervious zones, the inclined downstream drainage zone and downstream rockfill toe. The location and size of the downstream drainage zone was selected so as to provide sufficient area for the placement of adjacent fills expeditiously and to intercept seepage well within the embankment. Seepage through the foundation will be controlled by the foundation cutoff extending to bedrock in a limited reach of the valley and extending through surficial variable materials into the glacial till deposit in other reaches.

e. Foundation Design for Concrete Structures. The foundation for the concrete structures for the project will be either bedrock or compact glacial till. The foundation for the spillway weir, intake and outlet structures will be founded on bedrock. The outlet works conduit will be founded on compact glacial till material. No significant settlements are expected to occur in the foundations of concrete structures founded on these materials.

4. OTHER PLANS STUDIED

a. Local Protection of High Damage Areas. Local protection measures for flood control would involve channel widening and channel improvement of the brook all the way through the city. Studies reveal that local protection of concentrated loss areas is impracticable as an alternative to a flood control dam.

b. Channel Improvement of Beaver Brook. Estimates of annual benefits of this means of protection are about 70% of those for a reservoir project. The cost of such measures, including channel excavation, flood walls, earth dikes, riprap, drainage modifications, pumping stations, and the replacing of some 10 bridges are in excess of that for a flood control dam. Such a plan of improvement would also result in major disruption of the natural regimen of the city by requiring about 21 acres of residential, commercial and industrial properties, and acquiring several buildings within the limits of the protection works. In addition, there would be no downstream benefits to other localities from such a plan.

c. Diversion of Beaver Brook. Diversion of flood flows from Beaver Brook westerly into the Ashuelot River, or easterly into Otter Brook Reservoir is possible, but either of these diversions would be more costly than the recommended plan. A westerly diversion would have adverse effect as increase flows in the Ashuelot River would exceed the channel capacity through this part of the City and, in addition, would not reduce the effect of Ashuelot River backwater. An easterly diversion would reduce the storage effectiveness of Otter Brook Reservoir.

d. Modification of the Dam at West Swanzey. The hydraulic gradient of the Ashuelot is flat for a considerable distance below Keene. Hydraulic analysis reveals that modification of the dam at the downstream neighboring Town of Swanzey would have minor effect on the flood stages in the Keene flood plain and could not be justified.

e. Channel Improvement of the Ashuelot River. Consideration was also given to lowering the channel gradient of the Ashuelot River so that a higher rate of drainage and discharge could occur from tributaries emptying into the Keene flood plain. It would involve deepening the channel bed of the Ashuelot from Keene more than 20 miles downstream. The cost would be prohibitive and the plan of improvement would have no downstream benefits since increased discharges would cause greater losses along the Connecticut River.

5. COST ESTIMATES

a. Basis of Estimate. Topographic maps of the U. S. Geological Survey were supplemented by topographic surveys (2' contour interval) of the dam and reservoir areas. Foundation conditions were determined by subsurface explorations and field reconnaissance. Quantities of the principal construction items were estimated on the basis of design plans which would provide safe and adequate structures for the given conditions and hydraulic criteria. Unit

prices are based on average bid prices adjusted to June 1966 price level for similar work in the New England area.

b. Contingencies, Engineering and Overhead. To cover contingencies, construction and relocation costs have been increased by 15 percent rather than customary 25% owing to the extensive topographic and exploratory data accomplished. The costs of engineering, design, supervision and administration have been based on knowledge of the site and experience on similar projects.

c. Annual Charges. The estimate of Federal and Non-Federal annual charges was based on an annual interest rate of 3-1/8 percent plus the amount required to amortize the investment over the assumed 100-year life of the project. The investment equals the first cost since no interest charge accrues during the estimated construction period of two years. An allowance was made for maintenance and operation of the project and recreation facilities and for interim replacement of equipment having an estimated life of less than 100 years. No allowance was made for net loss of productivity of land since the real estate evaluation of lands includes an item for severance damage caused (1) as a result of partial taking of some properties and (2) by loss in value to some properties attributable to a reduction in utility of the remainder. Loss of taxes on land in Keene and Gilsum was not included as it is expected that enhancement of lands along the periphery of the proposed reservoir will offset any tax loss on land to be inundated.

d. Cost Estimates. A breakdown of costs of property and damages is given in Appendix D. A detailed cost estimate of the major construction items is given in Table No. C-2. A summary of construction expenditures and annual charges is given in Table No. C-3. Allocation of costs among project purposes, made by the separable costs-remaining benefit method, is shown in Table No. C-4. The initial apportionment of project costs between Federal and non-Federal interests based upon present applicable laws and regulations governing cost-sharing practices is given in Table No. C-5 indicating that the Federal Government would contribute toward the cost of lands, damages, and highway and utility relocations allocated to the project purpose of recreation. These costs have been adjusted to be the responsibility of non-Federal interests and a like amount is credited toward the non-Federal share of the apportioned water supply costs as shown in Table No. C-6.

6. PROJECT FORMULATION

a. General. The Beaver Brook project provides the most practicable and economic means for development of the water resources potential of the watershed. The evaluation of alternative plans

provides a basis for determining maximum net tangible benefits and provides a rationale for the project selected as the most effective development. Analysis indicated that construction of a single purpose flood control dam would not utilize maximum net benefits and that inclusion of recreation as a purpose would accrue additional benefits to the project. The city of Keene has ample water supply at the present time; however, population and growth projections indicate there will be a need for additional water supply in the future. The added potential afforded by future conversion of the recreation pool to water supply storage provides an optimum plan of development at reasonable cost. Provisions for fish and wildlife conservation are included in the project. A comparison of allocated costs and benefits accruing to project purposes in the recommended plan indicates that each project purpose is amply justified as shown in Table No. C-6.

b. Establishment of Project Purposes.

(1) Flood Control. The primary Federal interest in the construction of a multiple-purpose dam and reservoir on Beaver Brook is for the control of destructive flood damage in the urban areas of Keene, New Hampshire. Project formulation for flood control has been developed in accordance with Paragraph 1-77b of EM 1120-2-101. Preliminary studies indicate that 8.6 inches of flood control storage, or 2,750 acre-feet, would effectively control the standard project flood along Beaver Brook in the city of Keene and is justified in the multiple-purpose development. Average annual benefits attributable to flood control were computed for the Beaver Brook project acting after the completed Surry Mountain and Otter Brook Reservoirs. These benefits amount to $113,600 as shown in Table No. A-V of Appendix A.

(2) Water Supply. The need for additional water supply storage for municipal use is described in the report of the Federal Water Pollution Control Administration included in Appendix F. The drought conditions which currently prevail in this section of the country substantiate this need for inclusion of water supply as a project purpose. The inclusion of future water supply features was requested by the city of Keene. Although Keene has sufficient supply for present needs, consultants have concluded that the yield from ground water supply will be inadequate to meet future needs. Other alternate sources of water supply are considered to be of poorer quality than Beaver Brook.

Anticipated future demands are such that water supply provisions in the multiple-purpose dam are considered of prime importance. Water supply storage, in the alternate projects investigated, was varied to yield from 2.5 mgd (4.0 cfs) to 5.3 mgd (8.5 cfs) with

a 98-year dependability. Because the project life is 100 years, a 98-year dependability is equivalent to a 98 percent dependable yield. Plate B-11 (yield curves) was used to determine the amount of storage for the various assumed yields. Dead storage of 200 acre-feet was included in all projects studied to allow space for sediment deposition behind the dam. The discounted or average annual water supply benefits based on use of the pool from project year 20 to project year 100 amount to $20,100 annually and were derived as shown in Table No. C-8.

(3) Recreation. The recreational evaluation of the recommended plan is described in Appendix E. If the permanent pool is converted from recreational use to domestic water supply use (currently estimated at year 20), then visitation is expected to drop from 53,500 to 30,800 visitor-days annually. This use reduction would be caused by current State policy which does not permit water contact activities (swimming, motorized boating) in domestic water supply reservoirs. With water supply included, use or recreation facilities would be limited to picnicking, fishing, small boating and hiking. In either instance, costs and benefits for recreational development would be the same for the range of all pool areas studied. In the alternative purpose reservoir, not including provisions for future water supply storage, recreational benefits are not discounted but are taken for the full project life of the reservoir. Total recreation benefits include general recreation as well as fishery benefits attributable to lake fishing.

c. Project Formulation. A total of 25 combinations of varying flood control storages and water supply yields were evaluated in order to maximize net benefits for the project. A listing of the flood control storages and water supply yields used, is as follows:

Flood Control Storages	Water Supply Yields
4" 1276 Acre-Feet	2.5 mgd 800 Acre-Feet
6" 1914 Acre-Feet	3.0 mgd 1300 Acre-Feet
8" 2652 Acre-Feet	4.0 mgd 2200 Acre-Feet
8.6" 2750 Acre-Feet	4.4 mgd 2800 Acre-Feet
10" 3190 Acre-Feet	5.3 mgd 4550 Acre-Feet

Costs, benefits and excess of benefits over costs were derived for all 25 plans. A graphic representation of the analysis is shown on Plate No. C-7 of this appendix. The various water supply yields are plotted as functions of flood control storage vs. excess benefits. The curves indicate that the point of maximization of net benefits would be achieved with a reservoir containing approximately 8.6 inches of flood control storage and water supply capable of yielding 4.0 million gallons per day (mgd). A 98 percent dependable safe yield of 4.0 mgd will increase the existing supply to meet the peak demand of 11.0 mgd in the year 2010 as shown in the report of the Department of the Interior, Federal Water Pollution Control Administration included as Exhibit No. F-12 of Appendix F.

In order to evaluate the least costly alternate water supply storage, which in turn determines economic benefits on an annual basis, an analysis of well costs, in lieu of reservoirs, was made. Studies indicate that in the range between 4.0 mgd and 6.0 mgd, costs per mgd are minimized by constructing reservoirs. Any storage under 4.0 mgd or over 6.0 mgd could be more economically provided by wells if adequate ground water were available for the higher yields. The cost of wells was discounted to present worth for the first 20 years of project life in order to keep benefits comparable to reservoir storage which will not be used for water supply until year 20 of the project life.

A reservoir storage capacity of 2200 acre-feet will provide 4.0 mgd. However, a conservative estimate of between 2800 and 3000 acre-feet has been used in our study to allow for various losses such as evaporation, seepage and percolation. Flood control storage of 2750 acre-feet will provide for 8.6 inches of runoff and would effectively control the standard project flood.

d. Conclusion. It is concluded that the recommended Beaver Brook multiple-purpose dam and reservoir satisfies the present and future demonstrated needs for water resource development in the city of Keene and is directed toward achieving the best possible use of the resources employed. It provides an efficient vehicle for reducing future flood damages and for satisfying some of the demands for increased water supply and recreational facilities. The highest level of development with regard to scale, cost, timing and functional distribution has been obtained. All factors, both tangible and intangible as well as favorable and unfavorable, have been taken into account.

TABLE NO. C-2

BEAVER BROOK DAM AND RESERVOIR

DETAILED COST ESTIMATE

Item	Estimated Quantity	Unit	Price	Estimated Amount	Total
Lands and Damages					
Lands and Improvements	1	Job	L.S.	$162,000	
Contingencies				14,000	
Total Lands and Damages					$176,000
Relocations					
N. H. Route 10	1	Job	L.S.	$ 56,000	
Sullivan & Belvedere Roads	1	Job	L.S.	56,000	
Utilities	1	Job	L.S.	45.000	
Contingencies				23,000	
				180,000	
Engineering and Design				26,000	
Supervision and Administration				20,000	
Total Relocations					226,000
Reservoir Clearing					
Clearing	150	Acres	400.00	$ 60,000	
Contingencies				9,000	
				$ 69,000	
Engineering and Design				10,000	
Supervision and Administration				8,000	
Total Reservoir Clearing					87,000

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TABLE NO. C-2 (Cont'd)

Item	Estimated Quantity	Unit	Unit Price	Estimated Amount	Total
Dam					
Preparation of Site	9	Acres	$600.00	$ 5,400	
Stream Control	1	Job	L.S.	11,000	
Earth Excavation					
Stripping	31,000	C.Y.	.60	18,600	
Impervious	38,000	C.Y.	.70	26,600	
Random	32,000	C.Y.	.70	22,400	
Impervious Borrow	73,000	C.Y.	1.10	80,300	
Compacted Impervious Fill (Placing)	30,000	C.Y.	.40	12,000	
Compacted Pervious Fill	11,000	C.Y.	1.50	16,500	
Compacted Random Fill (Placing)	26,000	C.Y.	.30	7,800	
Rock Excavation	18,500	C.Y.	4.00	74,000	
Rock Slope Protection	19,000	C.Y.	2.00	38,000	
Gravel Bedding	13,000	C.Y.	2.00	26,000	
Concrete, Mass	2,500	C.Y.	40.00	100,000	
Concrete, Reinforced	150	C.Y.	100.00	15,000	
Treated Road Gravel	1,700	C.Y.	2.00	3,400	
5' x 5' Conduit	1	Job	L.S.	35,000	
24" R.C. Pipe	100	L.F.	15.00	1,500	
Gates and Machinery	1	Job	L.S.	10,000	
Miscellaneous Items	1	Job	L.S.	7,000	
Water Supply Features	1	Job	L.S.	14,000	
Contingencies				78,500	
				$603,000	
Engineering and Design				86,000	
Supervision and Administration				69,000	
Total Dam					$ 758,000
Water Control Structure					
Preparation of Site	1	Job	L.S.	$ 300	
Stream Control	1	Job	L.S.	300	
Stripping	1	Job	L.S.	500	
Random Fill (From Spillway Excav.)	4,000	C.Y.	$1.10	4,400	
Outlet Works	1	Job	L.S.	2,000	
Topsoiling and Seeding	1	Job	L.S.	1,200	
Contingencies				1,300	
				$ 10,000	
Engineering and Design				1,600	
Supervision and Administration				1,400	
Total Water Control Structure					13,000

TABLE NO. C-2 (Cont'd)

Item	Estimated Quantity	Unit	Unit Price	Estimated Amount	Total
Roads					
Access Road	1	Job	L.S.	$ 10,000	
Contingencies				1,500	
				$ 11,500	
Engineering and Design				1,500	
Supervision and Administration				1,000	
Total Access Road					$ 14,000
Recreation Facilities					
Facilities (see Table E-3)	1	Job	L.S.	$ 68,600	
Contingencies				13,400	
				82,000	
Engineering and Design				12,000	
Supervision and Administration				9,000	
Total Recreation Facilities					103,000
			TOTAL PROJECT FIRST COST		$1,377,000

NOTE: The above estimate does not include preauthorization costs of $43,000.

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TABLE NO. C-3

BEAVER BROOK DAM AND RESERVOIR

SUMMARY OF CONSTRUCTION EXPENDITURES AND ANNUAL CHARGES

	Multiple Purpose Project					Alternative Dual Purpose Projects			Alternative Single Purpose Projects		
	Specific Costs										
	Flood Control	Water Supply	Recreation	Joint Use Costs	Total Costs	Water Supply and Recreation	Flood Control and Recreation	Flood Control and Water Supply	Flood Control	Water Supply	Recreation
Permanent Features											
Lands and Damages				$ 176,000	$ 176,000	$ 161,000	$ 176,000	$ 176,000	$ 161,000	$ 161,000	$ 161,000
Relocations				226,000	226,000	226,000	226,000	226,000	226,000	226,000	226,000
Reservoir Clearing				87,000	87,000	87,000	87,000	87,000	7,000	87,000	87,000
Dams											
Main Dam				640,000	640,000	383,000	640,000	640,000	383,000	383,000	383,000
Outlet Works				98,000	98,000	98,000	98,000	98,000	20,000	98,000	98,000
Water Control Structure				13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Water Supply Features		$20,000			20,000	20,000		20,000		20,000	
Recreation Facilities			$103,000		103,000	103,000	103,000				103,000
Access Road				14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000
TOTAL PROJECT FIRST COST	$ 0	$20,000	$103,000	$1,254,000	$1,377,000	$1,105,000	$1,357,000	$1,274,000	$ 824,000	$1,002,000	$1,085,000
Investment and Annual Charges											
Construction Expenditures	0	20,000	103,000	1,254,000	1,377,000	1,105,000	1,357,000	1,274,000	824,000	1,002,000	1,085,000
Interest During Construction	0	0	0	0	0	0	0	0	0	0	0
Investment	0	20,000	103,000	1,254,000	1,377,000	1,105,000	1,357,000	1,274,000	824,000	1,002,000	1,085,000
Annual Charges											
Interest & Amortization (3.276%)	0	600	3,400	41,100	45,100	36,200	44,500	41,700	27,000	See	35,500
Operation and Maintenance											
Dam, Reservoir & Pool				5,700	5,700	4,200	5,700	5,700	4,200	Table	4,200
Recreation Facilities			5,000		5,000	5,000	5,000	0	0		5,000
Supervision & Administration				300	300	300	300	300	300	C-8	300
Inspection & Reports				400	400	0	400	400	400		0
Major Replacements	0	300	500	400	1,200	1,000	900	800	200		800
TOTAL ANNUAL CHARGES	$ 0	$ 900	$ 8,900	$ 47,900	$ 57,700	$ 46,700	$ 56,800	$ 48,900	$ 32,100		$ 45,800

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TABLE NO. C-4

BEAVER BROOK DAM AND RESERVOIR

ALLOCATION BY SEPARABLE COSTS - REMAINING BENEFITS METHOD

	Flood Control	Water Supply	Recreation	Total
1. ALLOCATION OF ANNUAL COSTS				
a. Benefits	$ 113,600	$ 20,100 (1)	$ 32,000 (2)	$ 165,700
b. Alternate cost	32,100	20,300	45,800	98,200
c. Benefits limited by alternate cost	32,100	20,100	32,000	84,200
d. Separable cost	11,000	900	8,800	20,700
e. Remaining benefits	21,100	19,200	23,200	63,500
f. Allocated joint cost	12,300	11,200	13,500	37,000
g. Total allocation, project cost	23,300	12,100	22,300	57,700
2. ALLOCATION OF OPERATION & MAINTENANCE COSTS				
a. Separable cost	1,900	0	5,000	6,900
b. Allocated joint cost	1,500	1,400	1,600	4,500
c. Total allocation O&M	3,400	1,400	6,600	11,400
d. Specific costs	0	0	5,000	5,000
e. Allocated joint use costs	3,400	1,400	1,600	6,400
f. Ratio for allocation of joint use O&M	53.1%	21.9%	25.0%	100%
3. ALLOCATION OF MAJOR REPLACEMENTS				
a. Separable cost	200	300	400	900
b. Allocated joint cost	100	100	100	300
c. Total allocation, major replacements	300	400	500	1,200
4. ALLOCATION OF INVESTMENT				
a. Annual investment cost	19,600	10,300	15,200	45,100
b. Ratio of annual investment	43.5%	22.8%	33.7%	100%
c. Allocated investment	599,000	314,000	464,000	1,377,000
5. ALLOCATION OF CONSTRUCTION EXPENDITURES				
a. Specific investment	0	20,000	103,000	123,000
b. Investment in joint use facilities	599,000	294,000	361,000	1,254,000
c. Construction expenditures in joint use facilities	599,000	294,000	361,000	1,254,000
d. Percent of construction expenditures in joint use facilities	47.8%	23.4%	28.8%	100%
e. Construction expenditures in specific facilities	0	20,000	103,000	123,000
f. Total construction expenditures	599,000	314,000	464,000	1,377,000
SUMMARY				
Total construction expenditures	599,000	314,000	464,000	1,377,000
Annual costs	23,300	12,100	22,300	57,700
Annual benefits	113,600	20,100	32,000	165,700
Benefit/cost ratio	4.9	1.7	1.4	2.9

(1) Water supply benefits discounted for period during which storage will be used for recreation only.

(2) Recreation benefits adjusted to reflect change in use after year 20.

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TABLE NO. C-5

INITIAL COST APPORTIONMENT

	Federal	Non-Federal	Total
First Costs			
Flood Control			
Lands & Damages	$	$ 84,000	$ 84,000
Relocations		108,000	108,000
Dam & Reservoir	407,000		407,000
Totals - Flood Control	$407,000	$ 192,000	$ 599,000
Recreation			
Lands & Damages	$ 51,000	$	$ 51,000
Relocations	65,000		65,000
Dam & Reservoir	245,000		245,000
Recreation Facilities	51,500 ✓	51,500 ✓	103,000
Totals - Recreation	$412,500	$ 51,500	$ 464,000
Water Supply			
Lands & Damages	$	$ 41,000	$ 41,000
Relocations		53,000	53,000
Dam & Reservoir		200,000	200,000
Water Supply Features		20,000	20,000
Totals - Water Supply	0	$ 314,000 ✓	$ 314,000
TOTAL FIRST COSTS	$819,500	$ 557,500	$1,377,000

	Interest & Amort.	Oper. & Maint.	Major Replace.	Total
Annual Charges				
Federal				
Flood Control	$13,300	$ 0	$ 0	$13,300
Recreation	13,500	0	0	13,500
Water Supply	0	0	0	0
Total - Federal	$26,800	$ 0	$ 0	$26,800
Non-Federal				
Flood Control	$ 6,300	$ 3,400	$ 300	$10,000
Recreation	1,700	6,600	500	8,800
Water Supply	10,300	1,400 ✓	400 ✓	12,100
Total - Non-Federal	$18,300	$11,400	$ 1,200	$30,900
TOTAL ANNUAL CHARGES	$45,100	$11,400	$ 1,200	$57,700

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TABLE NO. C-6

ADJUSTED COST APPORTIONMENT

	Federal	Non-Federal	Total
First Costs			
Flood Control			
Lands & Damages	$	$ 84,000	$ 84,000
Relocations		108,000	108,000
Dam & Reservoir	407,000		407,000
Totals - Flood Control	$407,000	$ 192,000	$ 599,000
Recreation			
Lands & Damages	$	$ 51,000	$ 51,000
Relocations		65,000	65,000
Dam & Reservoir	245,000		245,000
Recreation Facilities	51,500	51,500	103,000
Totals - Recreation	$296,500	$ 167,500	$ 464,000
Water Supply			
Lands & Damages	$	$ 41,000	$ 41,000
Relocations		53,000	53,000
Dam & Reservoir	116,000	84,000	200,000
Water Supply Features		20,000	20,000
Totals - Water Supply	$116,000	$ 198,000	$ 314,000
TOTAL FIRST COSTS	$819,500	$ 557,500	$1,377,000

	Interest & Amort.	Oper. & Maint.	Major Replacement	Total
Annual Charges				
Federal				
Flood Control	$13,300	$ 0	$ 0	$ 13,300
Recreation	9,700	0	0	9,700
Water Supply	3,800	0	0	3,800
Total - Federal	$26,800	$ 0	$ 0	$ 26,800
Non-Federal				
Flood Control	$ 6,300	$ 3,400	$ 300	$ 10,000
Recreation	5,500	6,600	500	12,600
Water Supply	6,500	1,400	400	8,300
Total - Non-Federal	$18,300	$ 11,400	$ 1,200	$ 30,900
TOTAL ANNUAL CHARGES	$45,100	$ 11,400	$ 1,200	$ 57,700

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TABLE NO. C-7

Economic Analysis

Purpose		Annual Benefits	Annual Costs	Benefit/Cost Ratio
Flood Control	121,600	$113,600	$23,300	4.9
Water Supply	21,500	20,100(1)	12,100	1.7
Recreation	34,200	32,000(2)	22,300	1.4
Total	177,300	$165,700	$57,700	2.9

(1) Water Supply benefits discounted for the period when storage will be used for recreational purpose only (assumed for first 20 years of project life.)

(2) Benefits for recreation discounted for period when storage is used for water supply and water contact sports eliminated.

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TABLE NO. C-8

BEAVER BROOK DAM AND RESERVOIR

SINGLE-PURPOSE WATER SUPPLY RESERVOIR

(To be built at Project Year 20 and serve as long as multiple-purpose project - 80 years)

For Alternative Cost		68 P.L. 4¾ 4⅜%
First cost	$1,002,000	1,125,000
Interest during construction	0	0
Total investment	$1,002,000	1,125,000
Annual Charges		
Interest and amortization (80 yrs.-3.416%) .04753	$34,200	53,500
Maintenance and operation	4,500	5,100
Major replacements:		
$20,000 at years 25, 50 and 75		
Present worth @ 3-1/8%:		
25 years ($20,000 x .46334) = $ 9,270	(.32293) = 6500	
50 years ($20,000 x .21469) = 4,290	(.10429) = 2150	
75 years ($20,000 x .09947) = 1,990	(.03365) = 700	
Total = $15,550	9,350 x .03753 = 10,250	
Capitol recovery ($15,550 x .03416 = .04753)	500	500
Total annual charges (20 years hence)	$ 39,200	59,100
Total worth (20 years hence) = $39,200 x 29.271 (21.041) =	$1,147,400	1,243,500
Present worth = $1,147,400 x .54041 (.40485) =	$ 620,100	503,500
Avg. annual cost = alt. cost = $620,100 x .03276 (.04513) =	$ 20,300	23,100
For Benefits		
Total investment	$1,002,000	1,125,000
Maintenance and operation: use 5%		
Present worth (80 yrs. @ 3.5%)		
$4500 x 26.749	$ 120,400	85,000
5100 x 16.667		

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Major replacements:

$20,000 at years 25, 50 and 75

Present worth @ 3⅛%:

25 years ($20,000 x .42315) =	$ 8,500	
50 years ($20,000 x .17905) =	3,600	
75 years ($20,000 x .07577) =	1,500	
Total present worth		$ 13,600

Total worth at project year 20 $1,136,000

Present worth at project year 0 (3-1/8%)

$1,136,000 x .54041 = $ 613,900

Avg. annual cost = annual benefits = $613,900 x.03276 = $20,100

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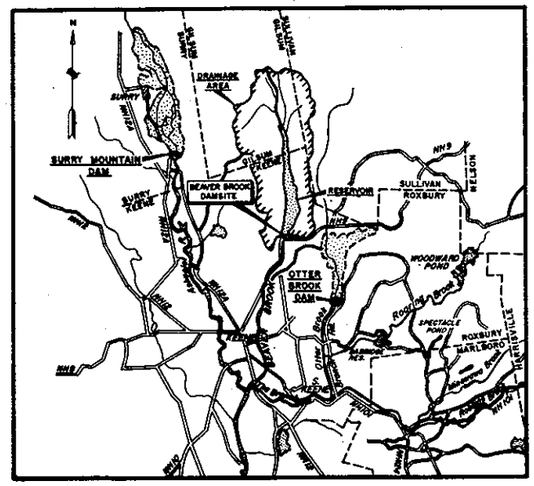
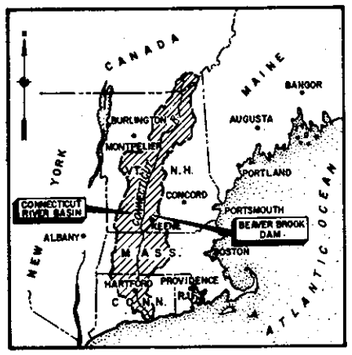


VICINITY MAP

SCALE IN FEET

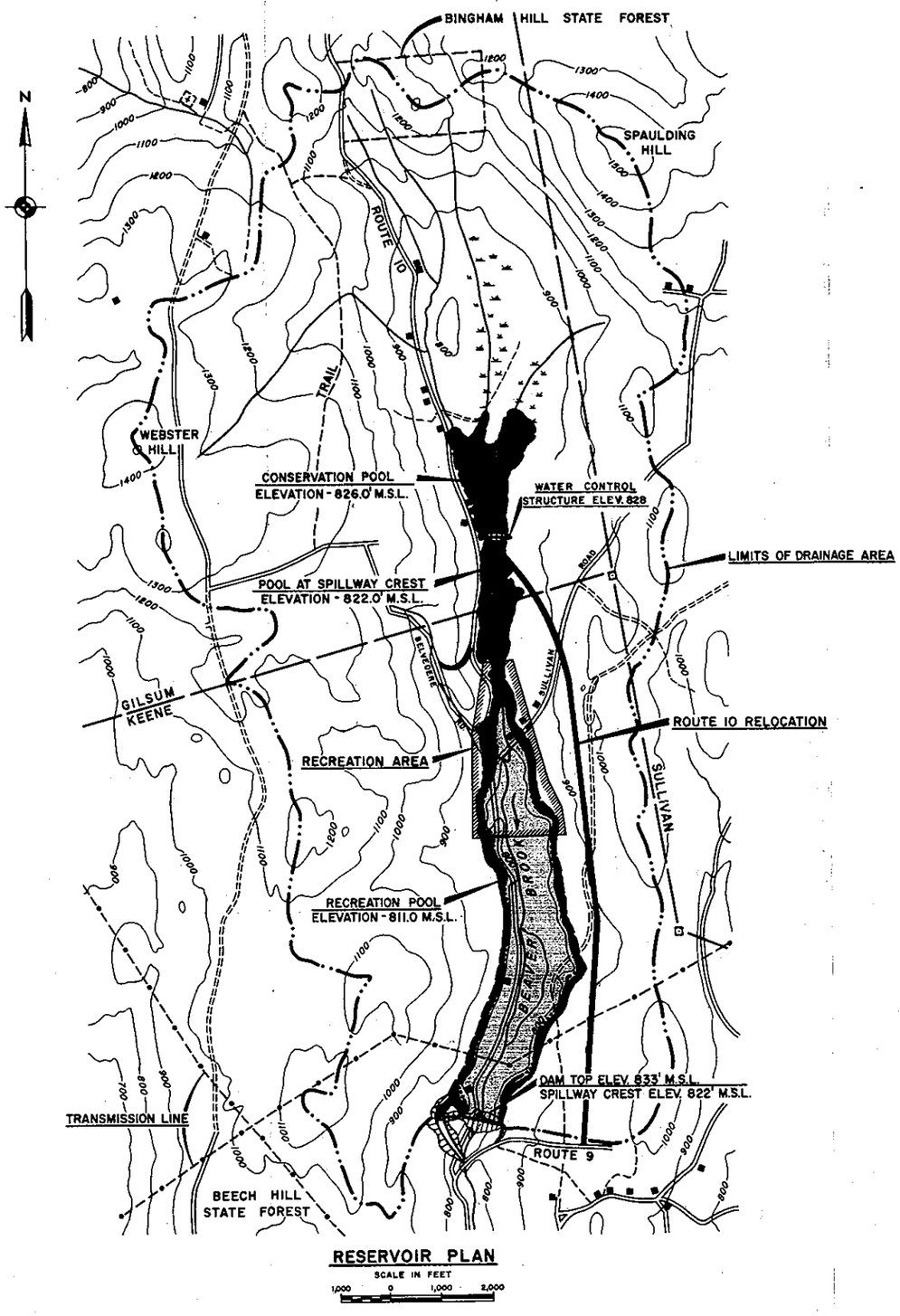
3000' 0 3000' 6000' 9000'



LOCATION MAP

SCALE IN MILES

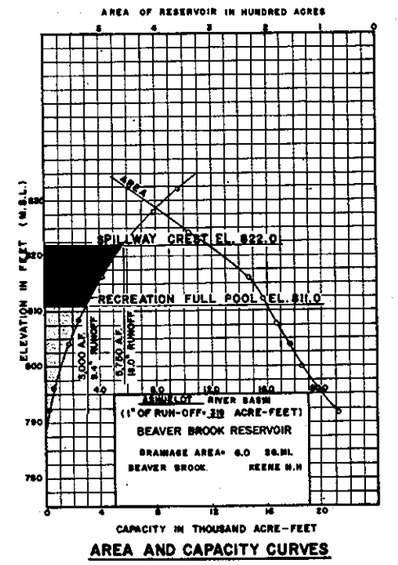
40 0 40 80



RESERVOIR PLAN

SCALE IN FEET

1,000 0 1,000 2,000



AREA AND CAPACITY CURVES

NOTE:

Route 10 in reservoir area to be relocated.
115 KV Transmission line to be relocated (6,000 L.F.).
Elevations refer to Mean Sea Level Datum.
Topography is based on Nov.-Dec. 1964 and Jan. 1965 survey by U.S. Army Corps of Engineers.

REVISION	DATE	DESCRIPTION	BY
△	3-6-67	Reservoir Plan and Vicinity Map Revised	

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY F.W.S. | DR. BY M.S. | CH'K'D

PROJECT ENGINEER

CHIEF, E & D. BRANCH

CONNECTICUT RIVER FLOOD CONTROL
KEENE, NEW HAMPSHIRE
BEAVER BROOK DAM
DRAINAGE AREA AND RESERVOIR PLAN
BEAVER BROOK, NEW HAMPSHIRE

APPROVED

CHIEF, ENGINEERING DIVISION

DATE NOV. 1966

SCALE: AS SHOWN

DRAWING NUMBER

TO ACCOMPANY REPORT
DATED: NOVEMBER 1966

PLATE NO. C-1

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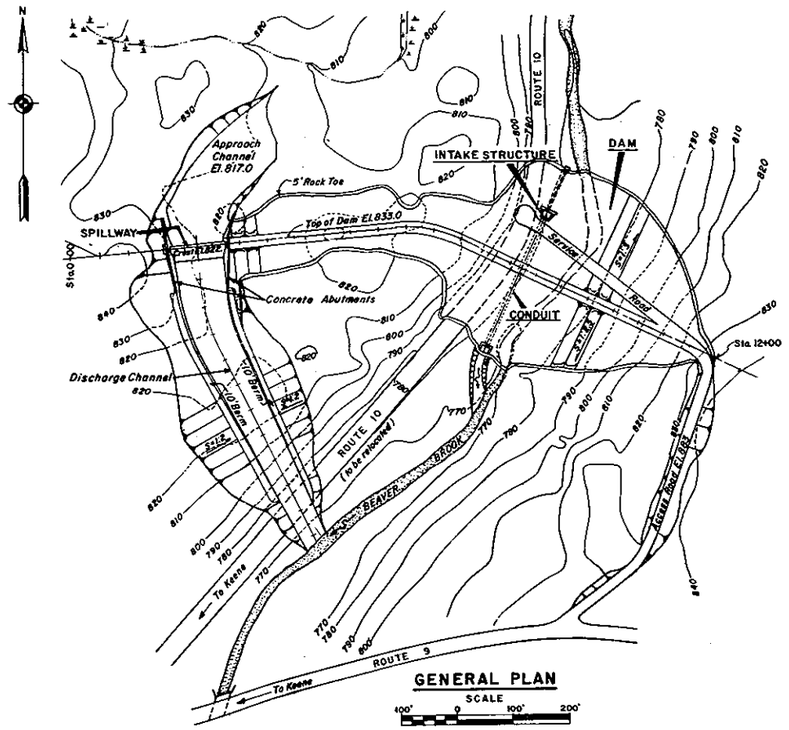
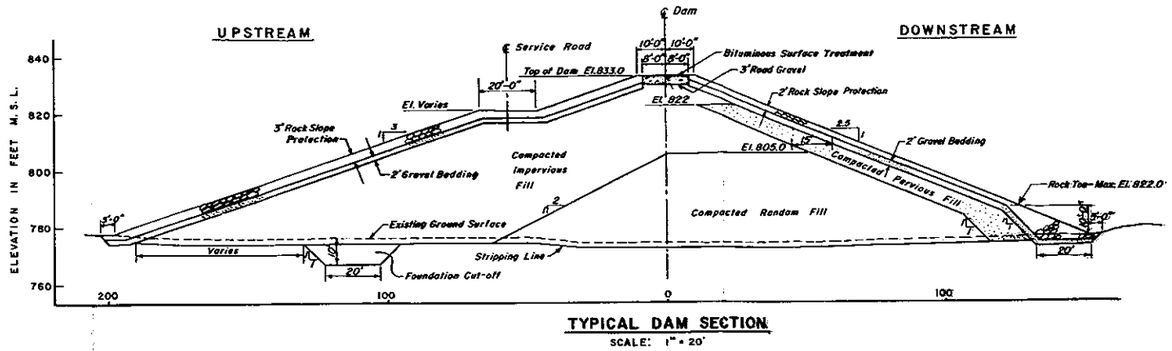


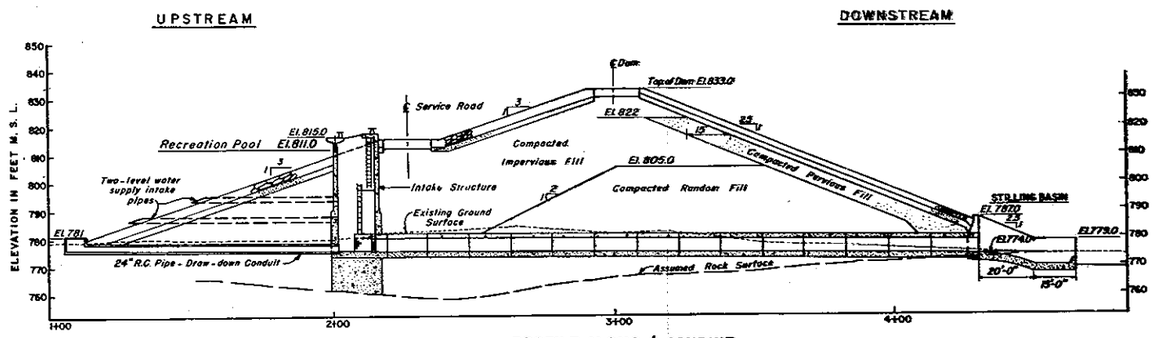
GENERAL PLAN

SCALE 400' 0 100' 200'



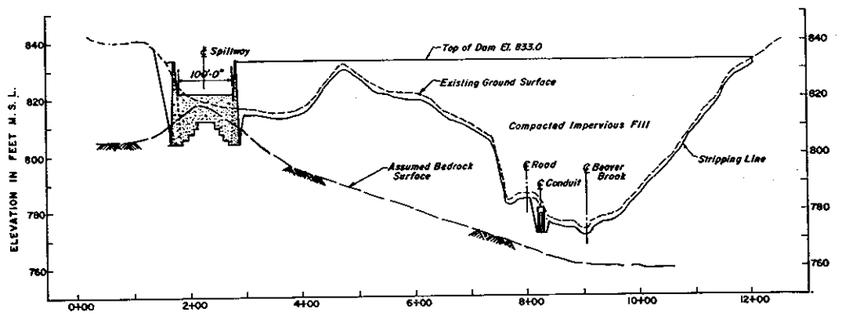
TYPICAL DAM SECTION

SCALE: 1" = 20'



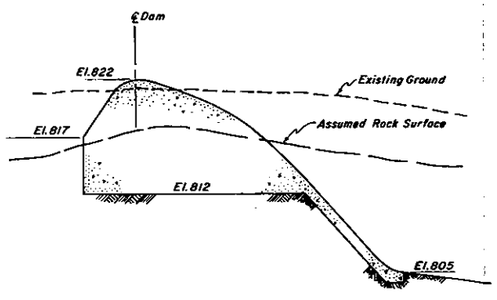
PROFILE ALONG ℄ CONDUIT

SCALE IN FEET 20' 0 20' 40'



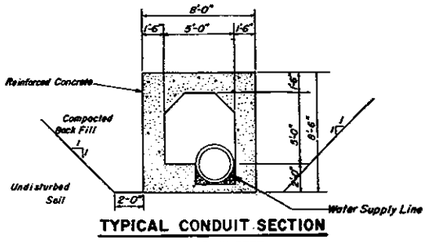
PROFILE THROUGH ℄ DAM

SCALE: 1" = 100' HORZ.
1" = 20' VERT.



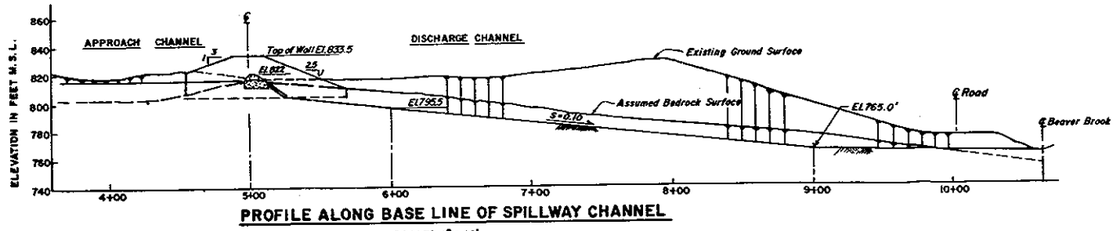
SECTION ALONG CENTER LINE OF SPILLWAY WEIR

SCALE IN FEET 5' 0 5' 10'



TYPICAL CONDUIT SECTION

SCALE IN FEET 4' 0 4' 8'



PROFILE ALONG BASE LINE OF SPILLWAY CHANNEL

SCALE: 1" = 40'

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY F.W.S. | DR. BY M.W.B. | CH. BY

PROJECT ENGINEER

RECOMMENDED:

CHIEF, P. & R. BRANCH

CONNECTICUT RIVER FLOOD CONTROL
KEENE, NEW HAMPSHIRE
BEAVER BROOK DAM
GENERAL PLAN AND SECTIONS
BEAVER BROOK, NEW HAMPSHIRE

APPROVED

CHIEF, ENGINEERING DIVISION

DATE NOV. 1966

SCALE AS SHOWN

DRAWING NUMBER

TO ACCOMPANY REPORT
DATED: NOVEMBER 1966

PLATE NO. C-2

CORPS OF ENGINEERS

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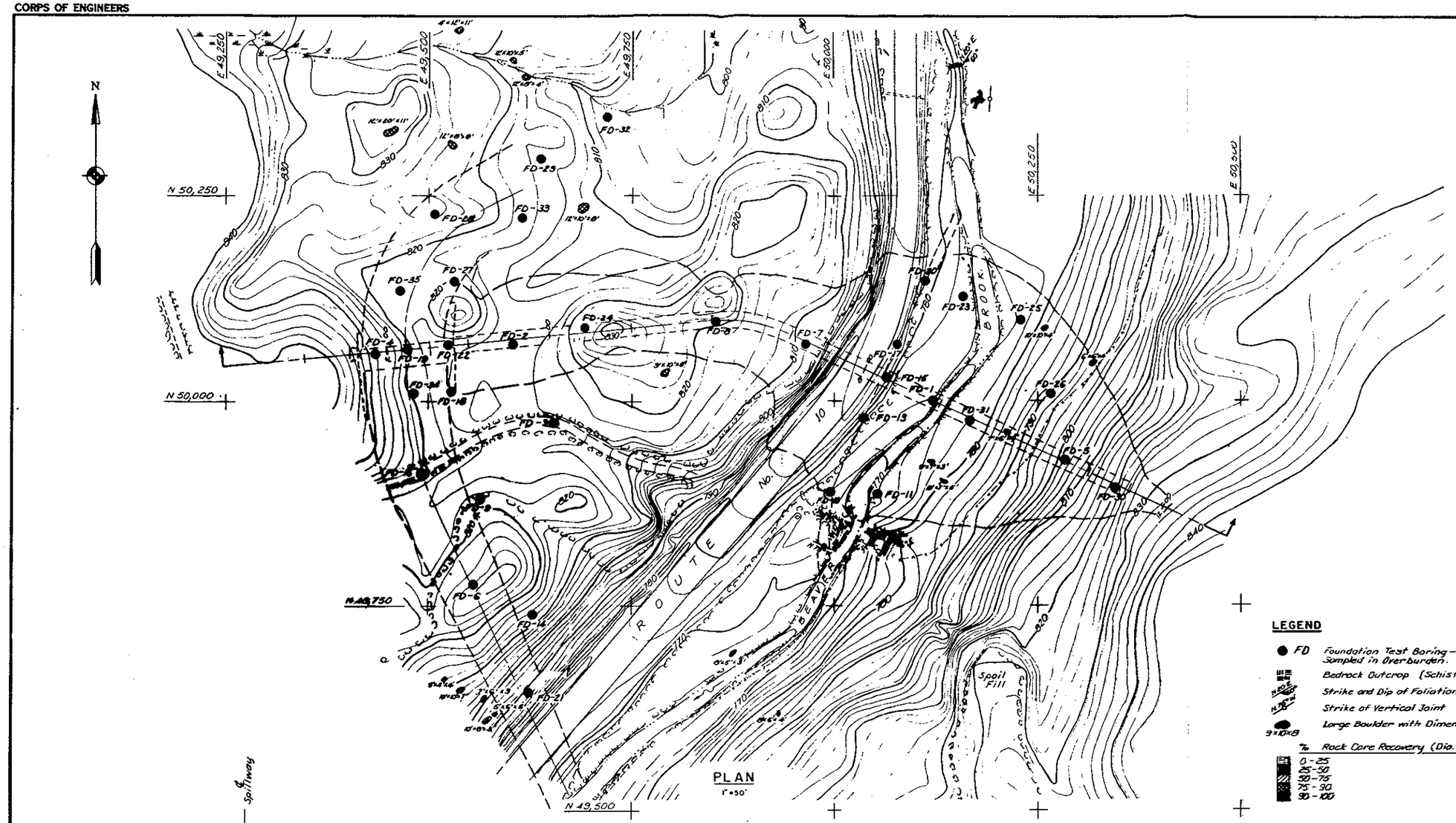

LEGEND

- FD — Foundation Test Boring — Continuously Drive Sampled in Overburden.
- Bedrock Outcrop (Schist)
- Strike and Dip of Foliation
- Strike of Vertical Joint
- Large Boulder with Dimensions
- % Rock Core Recovery (Dia. 2⅜")
  - 0 - 25
  - 25 - 50
  - 50 - 75
  - 75 - 90
  - 90 - 100

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

CONNECTICUT RIVER FLOOD CONTROL

BEAVER BROOK DAM

GEOLOGY

BEAVER BROOK, NEW HAMPSHIRE

DATE: NOV. 1966

TO ACCOMPANY REPORT DATED NOVEMBER 1966

PLATE NO. C-3

CORPS OF ENGINEERS

U. S. ARMY

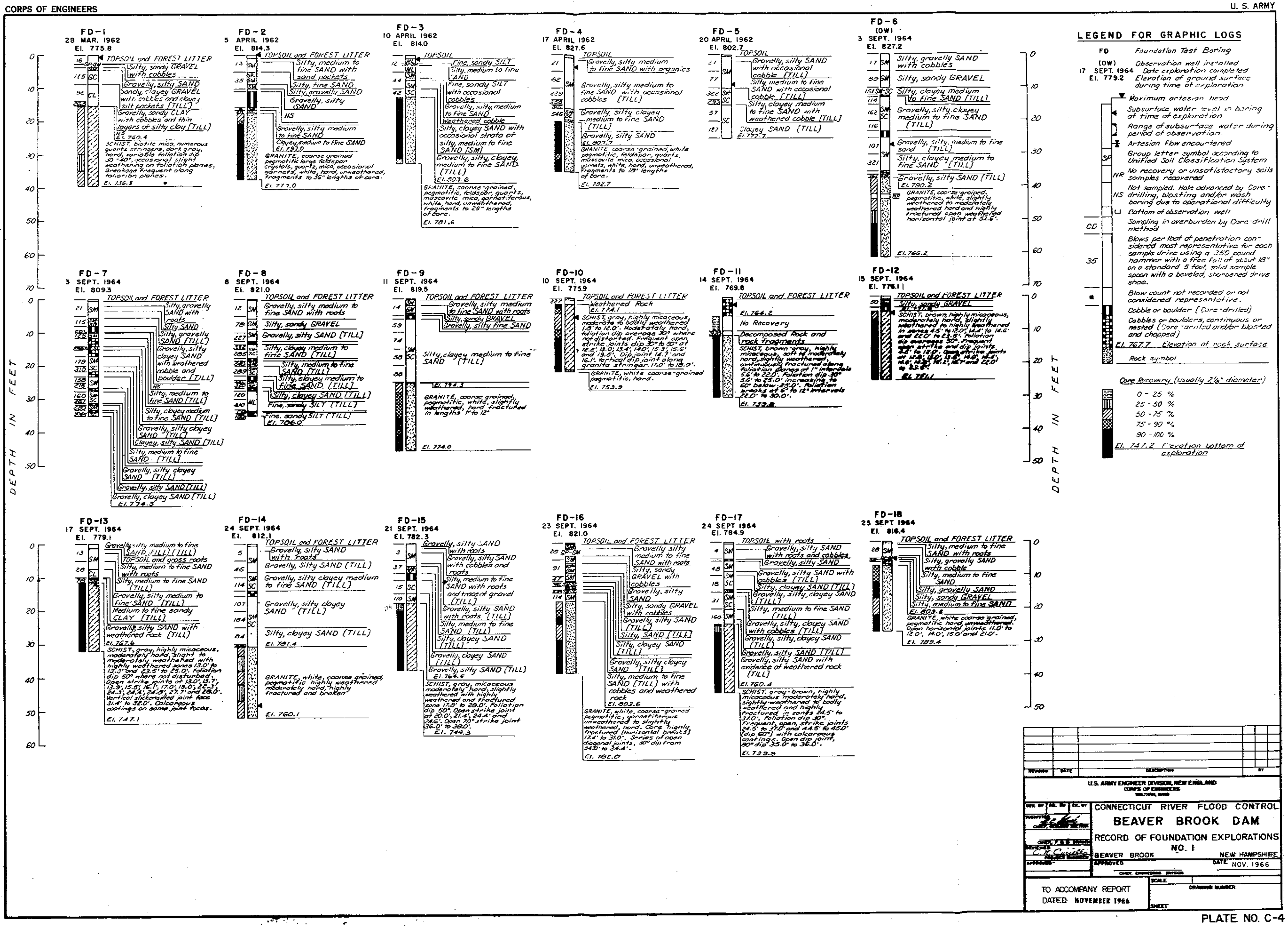

PLATE NO. C-4

CORPS OF ENGINEERS

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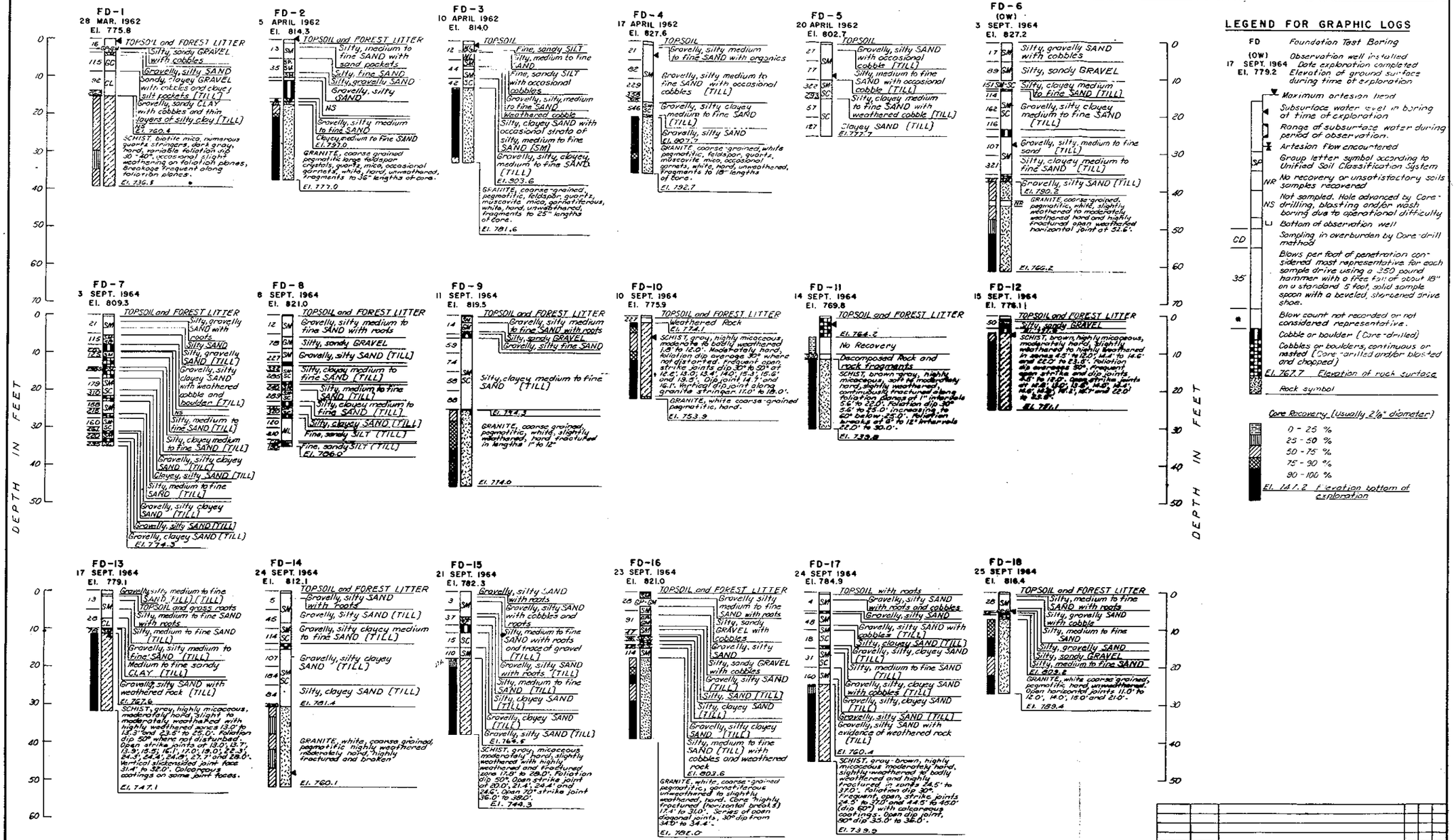


LEGEND FOR GRAPHIC LOGS

FD — Foundation Test Boring

(OW) — Observation well installed

17 SEPT. 1964 — Date exploration completed

El. 779.2 — Elevation of ground surface during time of exploration

- Maximum artesian head
- Subsurface water level in boring at time of exploration
- Range of subsurface water during period of observation.
- Artesian flow encountered
- SP — Group letter symbol according to Unified Soil Classification System
- NR — No recovery or unsatisfactory soils samples recovered
- NS — Not sampled. Hole advanced by Core-drilling, blasting and/or wash boring due to operational difficulty
- Bottom of observation well
- CD — Sampling in overburden by Core-drill method
- 35 — Blows per foot of penetration considered most representative for each sample drive using a 350 pound hammer with a free fall of about 18" on a standard 5 foot, solid sample spoon with a beveled, shortened drive shoe.
- * — Blow count not recorded or not considered representative.
- Cobble or boulder (Core-drilled)
- Cobbles or boulders, continuous or nested (Core drilled and/or blasted and chopped)

El. 767.7 — Elevation of rock surface

Rock symbol

Core Recovery (Usually 2⅛" diameter)

- 0 - 25 %
- 25 - 50 %
- 50 - 75 %
- 75 - 90 %
- 90 - 100 %

El. 141.2 — Elevation bottom of exploration

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CH. BY

CONNECTICUT RIVER FLOOD CONTROL

BEAVER BROOK DAM

RECORD OF FOUNDATION EXPLORATIONS NO. 1

BEAVER BROOK NEW HAMPSHIRE

APPROVED: DATE NOV. 1966

CHIEF, ENGINEERING DIVISION

TO ACCOMPANY REPORT DATED: NOVEMBER 1966

SCALE

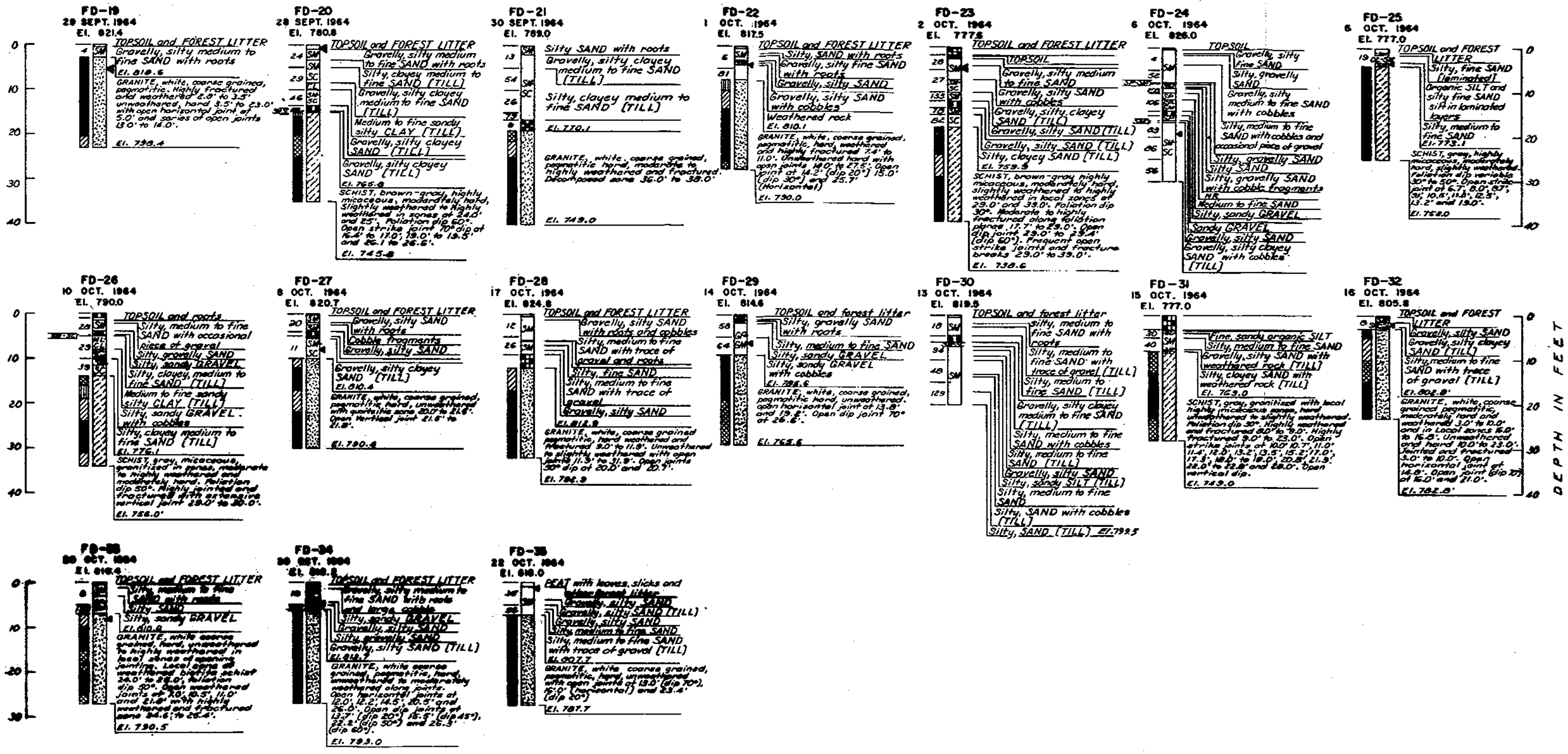
DRAWING NUMBER

SHEET

PLATE NO. C-4

CORPS OF ENGINEERS

U. S. ARMY



REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

CONNECTICUT RIVER FLOOD CONTROL

BEAVER BROOK DAM

RECORD OF FOUNDATION EXPLORATIONS
NO. 2

BEAVER BROOK — NEW HAMPSHIRE

DATE NOV. 1966

TO ACCOMPANY REPORT
DATED NOVEMBER 1966

PLATE NO. C-5

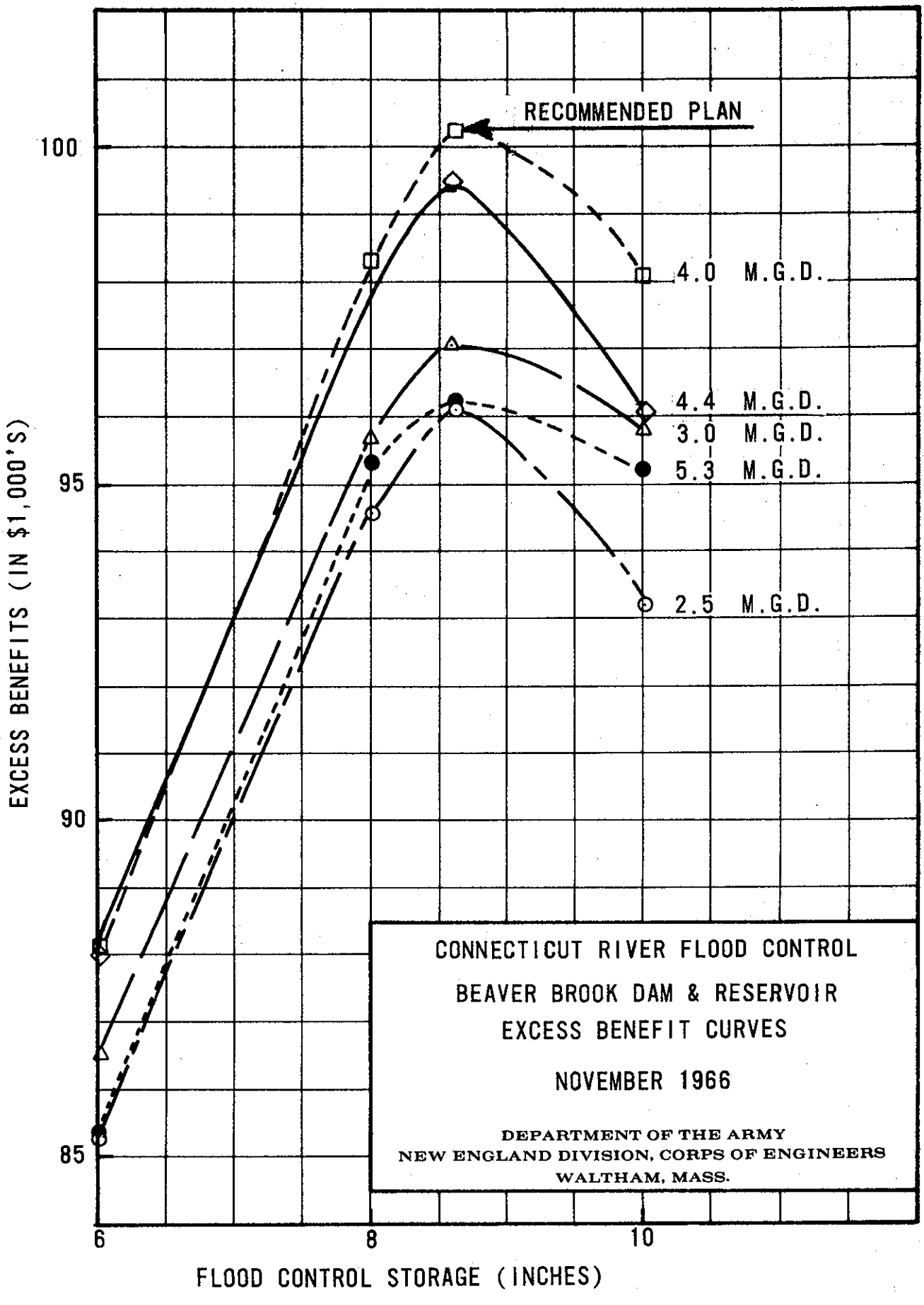

RECOMMENDED PLAN
100
95
90
85
EXCESS BENEFITS (IN $1,000'S)
4.0 M.G.D.
4.4 M.G.D.
3.0 M.G.D.
5.3 M.G.D.
2.5 M.G.D.
6
8
10
FLOOD CONTROL STORAGE (INCHES)
CONNECTICUT RIVER FLOOD CONTROL
BEAVER BROOK DAM & RESERVOIR
EXCESS BENEFIT CURVES
NOVEMBER 1966
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE NO. C-6

APPENDIX D

REAL ESTATE

APPENDIX D

REAL ESTATE

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APPENDIX D

REAL ESTATE

1. BEAVER BROOK DAM

a. Purpose. The purpose of this report is to estimate the real estate costs for the proposed Beaver Brook Dam and Reservoir, which currently is being planned as a multi-purpose dam and reservoir providing flood control, recreation facilities and future water supply. Real estate costs have been computed by establishing a minimum guide taking line at Elevation 828 m.s.l., pool area at maximum surcharge.

b. Location. The proposed dam is to be constructed on Beaver Brook, approximately three miles north of the business center of Keene, New Hampshire, and 1,100 feet north of the intersection of State Route 10 (Gilsum - Beaver Brook Road) and State Route 9. The reservoir area will extend upstream a distance of about 2-3/4 miles and will include lands within the City of Keene and Town of Gilsum, New Hampshire.

c. Description. The section of the City of Keene and Town of Gilsum in which the dam and reservoir are to be located is a rural residential area consisting of both year-round dwellings and summer cottages in the $2,000 to $13,500 price range. There are also two antique businesses and a State Highway Maintenance Department in the area as well as 617 acres of woodland some of which has been cut over.

d. Mineral and Crop Damage. The current field inspection of the area revealed no mining operation of minerals within the proposed area except for nearly depleted borrow areas for sand and gravel. The major portion of the land within the proposed reservoir limits is presently in woodland, bottomland and marsh land and is unsuitable for farming, homes and most other uses. An additional 11 percent of the area is under water. No crop damage is expected and present farmers would be allowed to gather any existing vegetation. There are a few small stands of merchantable species, but quality and quantity are considered inadequate to require inclusion of special allowances for merchantable timber.

e. Utilities. Telephone and electrical services are available along Route 10 (Gilsum-Beaver Brook Road), Sullivan West Road and Belvedere Road. The nearest point that city water is available is about 1.6 miles southerly of the dam site.

f. Relocations.

Cemeteries. No cemeteries were observed within the area of the proposed reservoir.

Roads. Land requirements for the relocation of Route 10 are included in this report.

Utilities. The existing transmission line, which presently passes through the proposed reservoir area, will be raised or relocated. No land requirements for utility relocations have been included in this report. All electrical and telephone lines will be relocated within the new highway right-of-way.

g. Removal of Channel Dams. There are three old fieldstone dams located within the proposed reservoir area. All of these dams are now breached. An allowance is included in real estate costs for removal of channel dams.

h. Scope of Field Work and Basis of Estimate of Valuation. The City of Keene's Assessor's Office and the County's Registry of Deeds Office were visited. The value estimates for improvements and land were developed through investigation and analysis of recent sales of property in the City of Keene and Town of Gilsum and from a general knowledge of real estate values in this area.

i. Acquisition Costs. The estimate of the number of tracts within the city which will be involved has been developed from the City Assessor's plans. Tracts within the Town of Gilsum were developed from a check of the records for property descriptions.

j. Severance Damage. A study of the preliminary maps of the subject reservoir, the City of Keene's Assessor's maps, the Town of Gilsum's Resident Property List and a field inspection of the area indicate that the taking of lands to Elevation 828 m.s.l. would leave approximately 250 acres on the west side of Route 10 without access.

Based on past experiences, the severance damages would approximate the fee value of the land. Detail mapping will probably indicate purchase of these areas will be the best real estate practice, and therefore, the value of complete tract is included in the lands to be acquired in fee. The proposed relocation of Route 10 will provide access to most properties severed on the east side of the existing Route 10 and thereby hold severance damage to a minimum. Included under contingencies is a sufficient amount for this item.

k. Valuation.

Improvements - Elevation 828 m.s.l.

2 Commercial Units	$11,500	
State-owned Highway Maintenance Area*	17,000	
13 Residences and outbuildings	46,200	
		$ 74,700

Land - Elevation 828 m.s.l.

Residential

Developed lots	27 A. @ $500	13,500	
Undeveloped lots	20 A. @ $300	6,000	
Commercial	5 A. @ $400	2,000	
State Highway Dept.	6 A.	2,500	
Cleared Land	55 A. @ $ 30	1,650	
Woodland	617 A. @ $ 50	30,850	
	730 A.		$ 56,500

*P.L. 85-500: 33USC 633

Removal of Channel Dams	4,000	
Severance (lands affected by loss of access included in fee takings)	-	
Contingencies 10% (including minor severance)	13,520	
Acquisition Costs (36 Tracts @ $750)	27,000	
		$ 44,520
		$175,720
Rounded to:		$176,000

l. Summary of Real Estate Costs.

	Elev. 828 m.s.l.
Improvement	$ 74,700
Land (Fee)	56,500
Removal of Channel Dams	4,000
Severance	-
Contingencies	13,520
Acquisition Costs	27,000
Total Rounded:	$176,000

Note: Total Real Estate Costs include land requirements for highway relocation of approximately 60 acres outside the proposed reservoir area and purchase of one additional tract. Total cost attributable to highway relocation is estimated to be $4,000. An additional 25 acres for work and borrow areas have also been included in the total.

m. Conclusions and Exceptions. The area to be acquired and the estimated values, as set forth in this report, are considered to be tentative in view of the lack of detailed ownership data and will be more fully discussed in the submission of the Real Estate Design Memorandum.

APPENDIX E

RECREATION

APPENDIX E

RECREATION

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APPENDIX E

RECREATION

1. DESCRIPTION

a. General

This appendix presents data to supplement the section of the main report relating to recreation and the development of recreation facilities. It includes a summary of existing recreation opportunity within the zone of influence of the project (a 40-mile radius), resources available for development, the means of meeting the needs for greater opportunity, and the plan of development including costs and benefits. Factors of population, income, available leisure time, tourist and vacation trends and distance have also been included. The scope of this appendix includes an evaluation of the public recreational potential as well as the fish and wildlife potential of the Beaver Brook reservoir area in relation to other recreational and fish and wildlife opportunities available to the public within the area which the project may be expected to influence.

b. Pertinent Data

With the ever-increasing demand for recreational pursuits, opportunities exist at this site for full consideration of outdoor recreation potential and fish and wildlife enhancement. The Beaver Brook project will have a pool of about 203 acres at elevation 811 feet, mean sea level, which can be used for full water-oriented recreation activities as well as provide a source for future water supply.

c. Fish and Wildlife Resources

The report of the U. S. Department of the Interior, Fish and Wildlife Service, included in Appendix F, concluded that the net overall effect of the project on fish and wildlife resources is beneficial. With the 203-acre conservation pool, a warm-water fishery resource will be created to consist primarily of chain pickerel, brown bullhead, large mouth bass, and other sun fishes. It is estimated that the average annual utilization of the reservoir fishery will be about 3,750 man-days or a net gain of 3,600 man-days over the existing use.

In order to mitigate wildlife resource losses which resulted from creation of the permanent pool, a water control structure would be located at the upper reach of the reservoir upstream from the relocated Route 10. The establishment of this pool would create conditions conducive to waterfowl management. The hunting opportunity presented by these birds would more than compensate for the loss of hunting opportunity now within the reservoir area. In addition, an incidental pickerel and bullhead fishery may become established.

d. Climate

The average temperatures for January and July in the vicinity of the project are 18°F and 69°F, respectively with a mean annual temperature of 45°F. Freezing temperatures begin in late October and end in early April. During the summer season, the maximum daily temperatures are 70°F or higher. Precipitation for the year averages about 39 inches and is well distributed among the seasons. The average annual snowfall is about 61 inches between the months of November to April.

2. FACTORS AFFECTING RECREATION ACTIVITIES

a. Population

The 1960 census figures show a total of 415,000 people residing in 140 cities and towns within a radius of 40 miles of the project; 120,000 people in 64 cities and towns reside within a 25-mile radius; and 31,000 people in 14 cities and towns within 10 miles of the project. Some of the principal population centers within an hour's drive of the project follow:

	Distance	Population (1960)
Brattleboro, Vermont	20	11,700
Keene, New Hampshire	3	17,600
Concord, New Hampshire	50	29,000
Manchester, New Hampshire	47	88,300
Nashua, New Hampshire	48	39,100
Fitchburg - Leominster, Massachusetts	38	71,000
Greenfield, Massachusetts	30	17,700
Gardner, Massachusetts	33	19,100

TABLE E-1

POPULATION DATA

	Within 10 Miles		Within 25 Miles		Within 40 Miles	
	1960	1950	1960	1950	1960	1950
New Hampshire	29,400	26,200	77,300	70,300	200,000	182,000
Vermont	1,600	1,400	37,400	35,200	58,500	57,000
Massachusetts	------	------	5,300	4,900	156,500	152,000
Total	31,000	27,600	120,000	110,400	415,000	391,000
Growth Rate	12.3%		8.7%		6.1%	

b. Income

The median incomes of families within a 10, 25 and 40-mile radius of the project were $5,700, $5,750 and $5,800 respectively, with about 75 percent of the families with incomes between $3,001 and $9,999 and about 11 percent with incomes over $10,000 (U. S. Census, 1960). This compares with a National median income of $5,660. Over 60 percent of the families belonging to this group desire and use public outdoor recreation areas which provide facilities for swimming and picnicking. This group is most responsive to using facilities when they are provided. Family and group use where facilities are available increases with income, the increase is the sharpest at about $3,000 a year, from thereon the participation steadily increases reaching a maximum in the $7,500 - $10,000 bracket then declining slightly thereafter (ORRRC Main Report, 1962).

c. Leisure Time

In special studies conducted by the Bureau of Labor, statistics confirm the trend toward a shorter than 40-hour week. All figures point to a continuation of this trend into the future. More time will be available to participate in outdoor recreation which will bring greater pressure upon existing facilities. It will also increase the demand for expansion of existing facilities and the development of new recreation facilities. As much as 20 percent of this leisure time, based on a 40-hour week, has some part focused upon areas with public outdoor recreation facilities. Greater opportunity is urgently needed in the densely-populated New England region to meet the mounting needs and demands of the majority of residents who are primarily skilled wage earners. With

a 200-acre lake adequately developed, a substantial part of the demand can be satisfied in the after-work and weekend hours at the Beaver Brook Reservoir area.

d. Tourist and Vacation Trends

Tourists and vacationers play a major role in the economy of the project area and for the State of New Hampshire as a whole. Reflecting the importance of recreation to the New Hampshire economy, and indicative of the growing demand for recreational opportunities, are figures complied by the American Express Travel Survey and the Federal Reserve Bank of Boston which showed that vacationists put about $275,000,000 in the New Hampshire economy in 1961. Statistics by the State of New Hampshire in their 1963 survey indicated that 78 percent of users of the New Hampshire State Park system are non-residents with 39 percent of the users coming from Massachusetts.

e. Accessibility

The project area is readily accessible to all sections of the region over a network of good roads and interstate highways which are constantly being improved and bringing recreation resources such as those at Beaver Brook within easy reach of an increasing population. State Routes 9 and 10, which pass adjacent to the reservoir area are major vacation routes of the region. The use of the automobile to reach areas where recreation opportunity is available confirms the assumption that distance travelled to reach a given recreation area is a controlling factor in its estimated visitation. Generally, most people will drive to areas within a 40-mile radius or an hour's driving time for after-work and day-use activities.

f. Demand

The demand for public outdoor recreation for the residents of the project's area of influence is generated by the most basic factor; that of population. With the high population density in this section of New England, it is anticipated that the intended development at the Beaver Brook reservoir would receive optimum use within 3 years of completion. This has been the experience at recreational developments at recently completed Federal flood control reservoirs in New England.

g. Supply

Located in one of the more scenic regions of New England, with a rural setting yet close to the populated centers, the Beaver

Brook reservoir would be an important factor in helping to satisfy the ever-growing recreational demands of the region.

The natural recreational resources are many and varied. The White, Green and Berkshire Mountains, the Connecticut and Merrimack Rivers and tributaries and the numerous lakes and ponds provide a strong and diversified appeal to visitors. Private industry has developed many extensive recreation areas. However, these areas are designed for vacationers and tourists and are beyond the means of the general public. Public facilities for swimming and other aquatic sports, particularly in the Keene area, are few.

At the National conference on State Parks in 1960, the State of New Hampshire reported that the present facilities in the area are not sufficient to meet the demands for recreational use and that the existing facilities are overused by about 30 percent and that limits had been set by the control of parking cars, the numbers of camping parties, etc. at several areas. The Massachusetts Department of Natural Resources also reports that many areas are heavily overused and that additional facilities are urgently needed.

Many of the existing recreation areas are currently approaching the ultimate development stage. Attendance figures over the past decade at State Parks indicate that many have reached a point of saturation and that the visitations have levelled off or even dropped. Where additional facilities had been added or new areas developed, an immediate marked increase in attendance was noted at the new or expanded area with little or no change of attendance at areas where no improvements were made.(see Table E-2).

h. Anticipated Public Use

Based on attendance records at State Parks and Corps Projects in the area, particularly nearby Otter Brook and Surry Mountain Reservoirs, it is estimated that the optimum recreational development at Beaver Brook would receive maximum public use. The creation of a 200-acre public water area would help satisfy the demand for water-based activities. Facilities for day-use type activities to include swimming, boating, picnicking, fishing, hiking, and sightseeing could be developed to accommodate about 53,600 annual visitors. This visitation could be expected within 3 years after project construction.

TABLE E-2

ANNUAL ATTENDANCE
AT
SELECTED PUBLIC RECREATION AREAS
(WITHIN A 40-MILE RADIUS)

YEAR	CORPS PROJECTS			STATE AREAS					
				New Hampshire (1)				Massachusetts	
	Hop. * Everett	Otter* Brook	Surry* Mtn.	Monad-nock	Miller	Mt. Sunapee	Wadleigh	Otter River	Erving
1964	107,600	46,800	38,400	47,795	18,534	221,755	11,081	Not	Available
1963	31,000	21,200	20,800	42,670	19,730	197,940	16,370	61,770	44,140
1962	-	16,000	13,000	43,800	17,610	207,580	14,490	57,080	47,750
1961	-	17,500	14,000	41,330	16,570	208,390	14,770	54,650	56,700
1960	-	2,000	13,000	46,480	18,950	179,500	21,210	51,030	47,320
1959	-	-	4,000	40,680	16,480	167,570	26,180	48,160	56,740
1958	-	-	-	39,890	19,490	186,930	20,620	43,500	51,550
1957	-	-	-	38,700	19,350	108,970	24,540	44,640	36,840
1956	-	-	-	41,250	14,890	150,330	23,090	36,460	41,990
1955	-	-	-	34,380	14,310	132,530	28,860	36,150	32,780
1954	-	-	-	25,870	14,480	132,670	12,690	45,020	24,590

* Does not include sightseers at the dam.

(1) In 1962, the State of New Hampshire opened Greenfield State Park. The recorded annual attendance follows: 1962 - 5,000; 1963 - 15,525; 1964 - 70,784.

The major activity would be swimming with picnicking next, followed by fishing, small boating, and hiking. The annual attendance was not derived by type activity, since in most cases the users participate in more than one activity. However, the following percentages based on surveys at other Corps projects in New England and the percentages used by National Park Service in determining facilities required for day use areas could be applied as to use of facilities:

Swimming	50%
Picnicking	40
Fishing	7
Small Boating	2
Hiking	1
Total	100%

Applying these percentages to the estimated annual attendance of 53,600 visitors, the breakdown would be as follows:

Bathers	26,800
Picnickers	21,500
Fishermen	3,600
Boaters	1,100
Hikers	600
Total	53,600 Visitors (annually)

Under current New Hampshire State policy, contact sports are not permitted in domestic water supply reservoirs. Until such time as Beaver Brook reservoir is used for water supply (estimated to be 20 years after project completion) full recreational use would be permitted. When the reservoir is utilized for water supply, recreational use would preclude water contact activities under present State policy thus limiting the recreational activities to picnicking, fishing, small boating, and hiking. Based on other existing Corps reservoirs and State Parks with similar use, it is estimated that the annual attendance would be about 30,800 visitors. It is estimated that Beaver Brook would be more attractive than the similar areas analyzed in that the picnic areas would be bordering an attractive pool.

When the Beaver Brook reservoir is used for water supply, the conservation pool may have a fluctuating water surface; the range of fluctuation depending on the rate of runoff during the summer months. Through the use of reservoir regulation in conjunction with the present water supply well system, it is proposed to maintain the water surface at a relatively constant level during the summer recreation season. This would allow uninterrupted use of the pool for boating and fishing and would not change the aesthetics of the area. During drought years, the water surface of the conservation pool may incure its maximum fluctuation

and drawdown in order to provide the necessary water supply needs to the City of Keene. It is estimated that serious fluctuations of the pool during drought years are so infrequent that they will not affect the overall recreational aspects of the project.

3. MEANS OF MEETING NEEDS

The construction of the Beaver Brook water resource project would create a recreation and fishery resource of importance to the inhabitants of the project area. The reservoir area is easily accessible by the heavily travelled State Routes 9 and 10 and would receive use not only from residents of the area, but also from other communities in the highly populous New England area. Areas attractive to family type recreation, especially during the summer months, would be developed around swimming, picnicking, and fishing as the most common activities. After work and weekend day-use would be the primary form of recreation use. By the development of facilities, an annual visitation of 53,600 could be accommodated. This would include 3,600 man-days of fishing and 50,000 user-days of all other recreation activities. The plan of development is shown on Plate E-1. The extent of recreational development is based on the day use expected at any one time on a normal summer Sunday and is derived from the estimated annual attendance. Facilities would be constructed to accommodate a design load of 800 persons.

Because of the precipitous terrain on either side of the pool, the reservoir area does not offer opportunities for the development of a major recreation area.

4. ECONOMIC EVALUATION

a. First Costs

The estimated first cost of the recreation development for the Beaver Brook reservoir is $103,000 and includes allowances for contingencies, engineering, and design and for supervision and administration and is based on 1966 price levels.

TABLE E-3

COST ESTIMATES - RECREATIONAL DEVELOPMENT
BEAVER BROOK RESERVOIR

Item	Quantity	Unit	Unit Price	Estimated Cost
Earthwork	10,000	c.y.	$ 1.00	$ 10,000
Parking Areas (double bit. surface)	9,000	s.y.	1.25	11,250

TABLE E-3 (Cont'd)

Item	Quantity	Unit	Unit Price	Estimated Cost
Picnic Tables	60	each	$ 90.00	$ 5,400
Fireplaces	30	each	75.00	2,250
Change House - Comfort Station	1	each	16,000.00	16,000
Pit-type Toilet	1	each	1,700.00	1,700
Drinking Water	1	Job	5,000.00	5,000
Beach Area	10,000	s.y.	1.00	10,000
Boat Ramp & Parking Area	1	Job	3,000.00	3,000
Selective Clearing & Landscaping	1	Job	4,000.00	4,000
				$ 68,600
		Contingencies		13,400
	Total Construction Cost			$ 82,000
	Engineering & Design			12,000
	Supervision & Administration			9,000
	TOTAL FIRST COST			$ 103,000

b. Annual Costs

The annual charges include interest and amortization at 3-1/8% interest rate over the economic life of the project estimated at 100 years, operation and maintenance over the 100 years of project life at a charge of $0.10 per visitor annually, and allowance for major replacements which include replacing 1/3 of the facilities every 25 years. These annual costs follow:

Annual Costs

Interest on Investment	$ 3,200
Amortization	200
Maintenance and Operation	5,000
Allowance for Major Replacements	500
TOTAL ANNUAL COSTS	$ 8,900

c. Annual Benefits

Annual recreation benefits are based on assigning a monetary value of $0.75 per visitor-day to the average annual attendance expected at the

project. This value represents a weighted average visitor-day value for such recreation activities as picnicking, swimming, boating, sightseeing, nature study and other outdoor pursuits. The benefits attributed to fishery resources as reported by the U. S. Fish and Wildlife Service are based on a monetary value of $1.00 per fisherman day.

Values for general recreation and for fish and wildlife for the first 20 years of the project, for the remaining 80 years of the project, and equivalent average annual benefits over the 100-year project life are shown below:

	Project Years 0-20 (without water supply)		Project Years 21-100 (with water supply)		Equivalent Average Annual Benefits
	Man-days	Value	Man-days	Value	
General recreation	50,000	$37,500	30,000	$22,500	$29,800
Fishing	3,600	3,600	800	800	2,200
Totals	53,600	$41,100	30,800	$23,300	$32,000

d. Wildlife Mitigation Measures

The Beaver Brook reservoir would permanently inundate about 203 acres of wildlife habitat including a productive 25-acre wetland area. Hunting opportunities amounting to 150 hunter-days are expected to be eliminated from the reservoir area.

To determine the economic advisability of mitigating measures of 150 hunter-days, a unit value of $4.00 per hunter-day was applied, resulting in an annual benefit of $600. The estimated cost of the water control structure amounts to $13,000 and annual charges are estimated at $500. Construction of mitigating measures is justified, resulting in a benefit-cost ratio of 1.2 to 1.

The unit value of $4.00 per hunter-day used above is justified on the basis that: the project is located in a highly populated zone and is in close proximity to the centers of population; the areas is heavily used by tourists and vacationers; hunting opportunities are limited in the area and are in great demand; the project would provide unlimited waterfowl and upland game resources; and, the recreation use potential of the project area provides for uniqueness, diversity and access.

Additional detailed studies of fish and wildlife resources would be conducted as necessary after project authorization for the conservation, improvement and development of these resources.

5. SEPARATION OF BENEFITS AND COSTS

a. Benefits

Limiting the recreational activities based on the use of water supply at year 20, general recreation benefits including the reduction in visitor-days amount to $29,800 annually. Benefits to fishery resources are reduced to $2,200 annually. Estimates are based on projected annual attendance and use of the recreation facilities to be provided and were derived as follows:

General Recreation:

Years 0 - 20	50,000 visitor-days @ $0.75 =	$37,500
Years 21 - 100	30,000 visitor-days @ $0.75 =	22,500
	Difference	$15,000

$15,000 x .4818[1] + $22,500 = $29,800

Fishing:

Years 0 - 20	3,600 fisherman-days @ $1.00 =	$3,600
Years 21 - 100	800 fisherman-days @ $1.00 =	800
	Difference	$2,800

$2,800 x .4818[1] + $800 = $2,200

[1] Represents present worth at 3-1/8% at year 20 of 14.707 x capital recovery factor of .03276.

b. Costs

The total separable first costs for recreation for jointly used facilities amount to $103,000. These costs, shared between general outdoor recreation and fishing, amount to $96,000 and $7,000, respectively, and were computed in ratio that the benefits ascribed to each aspect bear to the total recreational benefits. The manner of computation is shown as follows:

General Recreation:

$$\frac{\$29,800}{\$32,000} \times \$103,000 = \$96,000$$

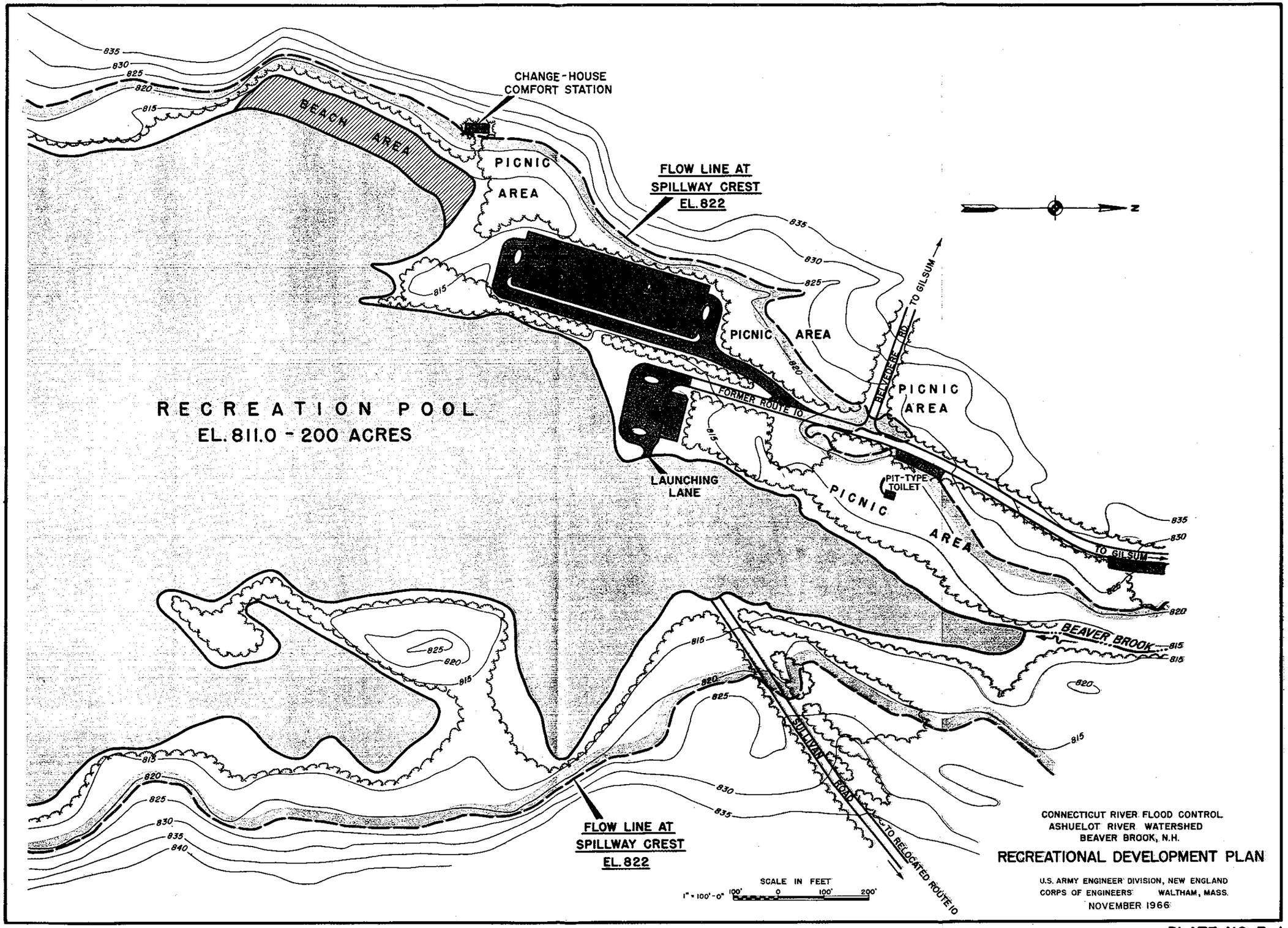
Fishing:

$$\frac{\$\ 2,200}{\$32,000} \times \$103,000 = \$\ 7,000$$

In accordance with the Federal Water Project Recreation Act of 1965 (Public Law 89-72), non-Federal interests are required to pay one-half the separable first costs of the project allocated to recreation and fish and wildlife enhancement, an amount currently estimated at $48,000 for general recreation and $3,500 for fishing.

CORPS OF ENGINEERS

U.S. ARMY



CONNECTICUT RIVER FLOOD CONTROL
ASHUELOT RIVER WATERSHED
BEAVER BROOK, N.H.

RECREATIONAL DEVELOPMENT PLAN

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS WALTHAM, MASS.
NOVEMBER 1966

PLATE NO. E-1

APPENDIX F

LETTERS OF COMMENT AND CONCURRENCE

APPENDIX F

LETTERS OF COMMENT AND CONCURRENCE

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Exhibit No.		Letter Dated
F- 1	New Hampshire Water Resources Board	25 May 1965
F- 2	New Hampshire State Planning Project	21 June 1965
F- 3	New Hampshire Dept. of Public Works and Highways	30 Apr 1965
F- 4	City of Keene (Including Inclosure)	29 Apr 1965
F- 5	U. S. Department of the Interior, Bureau of Mines	22 Jan 1962
F- 6	Federal Power Commission	2 Feb 1962
F- 7	U. S. Department of Health, Education and Welfare	17 Apr 1962
F- 8	U. S. Department of Commerce, Bureau of Public Roads	25 May 1965
F- 9	U. S. Department of the Interior, National Park Service	9 June 1965
F-10	U. S. Army Corps of Engineers	11 June 1965
F-11	U. S. Department of Agriculture, Soil Conservation Service	23 June 1965
F-12	U. S. Department of the Interior, Federal Water Pollution Control Administration	23 June 1966
F-13	U. S. Department of the Interior, Fish and Wildlife Service	3 Sept 1965

STATE OF NEW HAMPSHIRE

WATER RESOURCES BOARD

STATE HOUSE ANNEX
CONCORD 03301

May 25, 1965

Mr. John Wm. Leslie
Chief, Engineering Division
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Leslie:

We have considered your proposal for the construction of a multiple-purpose dam and reservoir including flood control, recreation, fish and wild life and for future water supply on Beaver Brook in the City of Keene, New Hampshire.

We believe that this plan best provides for the area and we urge early construction.

Very truly yours,

Walter G. White
Chairman

wgw:c
cc: Mr. Saia
Mayor Mallat
Congressional Delegation

EXHIBIT NO. F-1

STATE OF NEW HAMPSHIRE
JOHN W. KING, GOVERNOR

STATE PLANNING PROJECT

THIRTY-FOUR BRIDGE STREET, CONCORD, N. H. TELEPHONE CAPITOL 56611

June 21, 1965

Mr. John Wm. Leslie
Chief, Engineering Division
U. S. Army Engineer Division, New England
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Leslie:

In response to your request of April 26, 1965, we hereby submit our comments and evaluation of the proposed Beaver Brook multiple-purpose dam and reservoir at Keene, New Hampshire.

The State Planning Project favors construction of the Beaver Brook Project on the grounds that it will provide additional flood protection for residents of the flood plain downstream in Keene.

We are pleased that provisions will be made for the City of Keene to use the impoundment waters for a water supply should the need arise. This project is an excellent example of multiple use of a flood control project that will benefit the public in many ways.

The Project believes that public recreational facilities should be provided on the proposed 200 acre pool to be created at the Project. A water body of this size is of significant recreational value for boating, swimming, and other recreational activities. Recreational facilities should include a boat launching ramp, small swimming beach, picnic area, and related features such as parking areas, toilets, and running water.

We view the recreational development at Beaver Brook as of "local significance" only - the area will be used mainly by residents of Keene and adjoining communities. The Beaver Brook Project should have recreational facilities secondary in scope to those at nearby Otter Brook and Surry Mountain Reservoirs. Surry Mountain Reservoir has excellent potential for further recreational development while the state park at Otter Brook Reservoir already offers a well-developed recreation area for public use.

Should the recreational facilities at Beaver Brook Project receive heavy use, then additional facilities should be provided to meet the demands. We suggest that in the Corps' initial stages of planning for the recreation area, that sufficient lands be acquired to insure that land will be available for future expansion of recreation facilities.

The Project recommends that serious consideration be given to the acquisition of the land between the flood control reservoir boundary and the proposed relocation of Route 10 to the east of the project. This purchase would obtain land that might be developed for recreation use in the future, would prevent unsightly development from occurring near the shores of the proposed pool, and would assure that the lands adjoining the east side of the pool would be retained in natural condition.

Thank you for the opportunity to present our comments on your proposed multiple-purpose flood control development at Beaver Brook, Keene, New Hampshire.

Sincerely,

Mary Louise Hancock

Mary Louise Hancock
Project Director

MLH:dh

EXHIBIT NO. F-2
Page 2 of 2

STATE OF NEW HAMPSHIRE
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
CONCORD

JOHN O. MORTON
COMMISSIONER

ROBERT H. WHITAKER
DEPUTY COMMISSIONER
AND CHIEF ENGINEER

April 30, 1965

Mr. John Wm. Leslie
Chief, Engineering Division
U.S. Corps of Engineers
424 Trapelo Road
Waltham, Mass. 02154

Dear Mr. Leslie:

I have at hand your letter of April 26 relative to the Corps' latest proposal for constructing the Beaver Brook Flood Control project as a multi-purpose dam and reservoir including flood control, recreation, fish and wildlife and water supply provisions.

The Department has worked closely both with the City of Keene and with the Corps in connection with the Beaver Brook project since it was initially proposed. You may be assured that my staff and I will continue to render full co-operation in this matter.

The Department will gladly adjust its schedule for the reconstruction of Route 10 to meet any timing which the Corps may require.

Sincerely,

John O. Morton
Commissioner.

JOM/r
c.c.
F.M. Auer
A.P. Miller

EXHIBIT NO. F-3

CITY OF KEENE

NEW HAMPSHIRE

OFFICE OF THE CITY MANAGER

FRANK R. SAIA
City Manager

TELEPHONE
603-352-5211

April 29, 1965

United States Army Engineer Division, New England
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Att.: Colonel E. J. Ribbs
Acting Division Engineer

RE: Beaver Brook Dam and Reservoir Project
City of Keene, New Hampshire

Your Reference: NEDED-D

Dear Colonel Ribbs:

Enclosed for your information please find a copy of a Resolution adopted by the Keene City Council approving a multi-purpose dam project for Beaver Brook in accordance with recommendations of the U. S. Army Corps of Engineers.

We are urging you, and other governmental agencies involved, to make every effort to expedite this much needed project for inclusion in the 1965 "Omnibus Bill."

Your efforts will be appreciated.

Very truly yours,

CITY OF KEENE

By

Frank R. Saia
City Manager

FRS:ldw

Attachment: City of Keene Council Resolution
relating to: Beaver Brook Dam

ALL-AMERICA CITY
KEENE
NEW HAMPSHIRE

EXHIBIT NO. F-4

CITY OF KEENE

IN THE YEAR OF OUR LORD ONE THOUSAND NINE HUNDRED Sixty-Five

A RESOLUTION Relating To: Beaver Brook Dam

Resolved by the City Council of the City of Keene, as follows:

That the City Council request the United States Corps of Engineers to proceed with a multi-purpose Beaver Brook Dam to include recreational features and to be sought by Survey Report from the Omnibus Bill of 1965, or subsequent Omnibus Bills;

That it is apparent that the financial requirements of the City for the original dam proposal, if and when extended to water supply and recreation, could be as high as $780,000.00 with a minimum present requirement of $281,000.00 for flood control only;

That the new multi-purpose dam proposal could result in an outlay by the City of $115,000.00 to $230,000.00 depending on the amount of State participation;

That the maintenance of the dam will be the responsibility of the Federal Government;

That the inclusion of recreation in the new proposal will recuire operation and stewardship by the State or City of the recreational facility only, and

That we strongly urge all possible action by City officials as well as the Governor and the Congressional Delegation to get this Survey Report in to the 1965 Omnibus Bill.

Robert L. Mallat, Jr. /s/
Mayor

PASSED April 15 1965

A true copy, Attest: [signature]
City Clerk Keene New Hampshire
April 30 1965

EXHIBIT NO. F-4
Inclosure

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
REGION V

OFFICE OF
REGIONAL DIRECTOR

4800 FORBES AVE.
PITTSBURGH 13, PENNSYLVANIA

January 22, 1962

Brig. Gen. Seymour A. Potter, Jr.
Division Engineer
U. S. Army Engineer Division
New England
Waltham 54, Massachusetts

Dear General Potter:

Thank you for advising us of the public hearing to be held at Keene, N.H., on February 7, 1962, concerning flood protection along Beaver Brook, near Keene. While we will be unable to attend, we shall be interested in the conclusions reached.

The proposed dam and reservoir are in a pegmatite mining area from which feldspar, beryl, mica and other minerals are actively recovered. A large number of these pegmatites occur throughout the mining region. However, it is believed that because of its small extent, the reservoir would cover relatively few of such potential mineral sources.

The project also would provide needed flood protection to the vicinity of Keene, as well as some flood protection in the Ashuelot and Connecticut River Valleys.

Very truly yours,

Earle P. Shoub
Regional Director
Region V

EXHIBIT NO. F-5

FEDERAL POWER COMMISSION
REGIONAL OFFICE
290 BROADWAY
NEW YORK 7, NEW YORK

February 2, 1962
Ref: Your File NEDGW

Division Engineer
U. S. Army Engineer Division, New England
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Subject: Beaver Brook Dam, Keene, New Hampshire

Dear Sir:

Reference is made to your letter dated January 15, 1962, requesting our views with respect to possible power development at the proposed Beaver Brook flood control project near Keene, New Hampshire.

Our staff has reviewed the pertinent data furnished with your letter and has investigated the possibility of developing power at the potential site. In view of the small drainage area controlled (5.5 square miles) and the absence of dependable flow and head, it is concluded that power development in conjunction with flood control at the proposed Beaver Brook dam and reservoir would not be practicable nor economically feasible.

Sincerely yours,

D. J. Wait
Regional Engineer

By John A. Sherman
Acting

EXHIBIT NO. F-6

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
REGIONAL OFFICE

PUBLIC HEALTH SERVICE

REGION II
42 BROADWAY
NEW YORK 4, N. Y.

April 17, 1962

In reply refer to:
24:WPC

Mr. John Wm. Leslie
Chief Engineering Division
U.S. Army Engineer Division, New England
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear Mr. Leslie:

Reference is made to your letter of January 15, 1962 requesting the Public Health Service to investigate the need for storage in the proposed Beaver Brook reservoir, which will be located 1 1/2 miles north of Keene, New Hampshire. This office has initiated a study of the need for storage to permit low flow augmentation for downstream water quality control consistent with Public Law 87-88, and the need for domestic and industrial water supply storage consistent with Public Law 500 - III. This letter is written to indicate the current status of our study.

During our preliminary investigation all available information has been studied and appropriate state and local authorities with knowledge relative to the water supply and pollution control needs of the area in question have been contacted. On the basis of information secured to date, we believe that several tentative conclusions should be brought to your attention at this time:

1. This office does not believe that there is a need for inclusion of storage within the Beaver Brook reservoir to permit flow augmentation for water quality control. While occasional water quality nuisances have occurred in the past, the state of New Hampshire considers

the quality to be adequate for anticipated water usage and, as a consequence, does not foresee the need for other than primary treatment in the Keene area within the foreseeable future.

2 - Preliminary investigations indicate that the city of Keene, New Hampshire is the only community below the proposed Beaver Brook Dam and above the confluence of the Ashuelot River with the Connecticut River that will require storage to meet anticipated municipal and industrial water supply demands.

3 - While the safe yield of the existing Keene system is 3.5 mgd, preliminary estimates indicate that the water supply demand will increase on the average from about 2.6 mgd to 6 mgd within the next fifty years. Therefore, development of an additional source of supply with a safe yield of at least 4.0 mgd appears desirable.

4 - Current estimates indicate that 3,000 to 3,300 acre feet of storage within the Beaver Brook pool will provide a safe yield of 4.0 mgd. While additional studies will be required to define the future requirements of the city of Keene and alternate sources of supply including wells, adjacent surface water supplies and/or further development of the watersheds currently being tapped by the city of Keene, preliminary findings strongly suggest that the development of water supply storage in the Beaver Brook reservoir will be the most feasible source

of additional supply for the city of Keene.

Our future plan of action calls for a field trip to Keene and vicinity during May. We hope that this trip will be sufficient to adequately determine the future water supply demands of the city of Keene as well as to facilitate the study of alternate sources of ground and surface water supplies. An estimate of reimbursable costs on this project has been developed which we will wish to discuss with you in the near future.

Since we understand that your report is scheduled for completion by June 30th, we are attempting to expedite our water supply study and are aiming at submission of a final report by June 15, 1962. However, if your completion date is rescheduled, we would prefer to complete this study during the first quarter of fiscal year 1963. This would be of assistance relative to our current work load and would assure adequate coverage of the problem in the event that more than one field trip is required. Accordingly, we would appreciate being advised in the event that the completion dates for this project can be rescheduled.

Sincerely yours,

Everett L. MacLeman

Everett L. MacLeman
Acting Regional Program Director
Water Supply and Pollution Control

REGION ONE
CONNECTICUT
MAINE
MASSACHUSETTS
NEW HAMPSHIRE
NEW JERSEY
NEW YORK
RHODE ISLAND
VERMONT
PUERTO RICO

U. S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
3 Capitol Street
Concord, New Hampshire 03301

NEDED-D

May 25, 1965

Mr. John Wm. Leslie
Chief, Engineering Division
U. S. Army Engineer Division
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Leslie:

Reference is made to your letter of April 26, 1965 requesting our comments and evaluation of a proposal for the construction of a multiple-purpose dam and reservoir, including flood control, recreation, fish and wildlife, and water supply provisions, on Beaver Brook, near Keene, New Hampshire.

Since our interests are primarily in the highway field, our comments have been limited to the effect of the proposal on existing highways in the immediate vicinity.

The construction of the dam would necessitate the relocation of a section of existing Route 10 approximately three miles in length. It is feasible to construct this section of highway on new location to the east of the dam and reservoir site without creating any appreciable indirectness to the traveling public. Based on preliminary estimates prepared by the New Hampshire Department of Public Works and Highways, the construction cost would be only slightly higher than reconstruction on the present location. The present condition of the highway is such that reconstruction in the immediate future is warranted.

The New Hampshire Department of Public Works and Highways has completed field studies and is now progressing the design work for the relocation of Route 10. The highway reconstruction can therefore be scheduled to meet the construction of the dam.

In summation, with the possible exception of a slightly higher cost for the construction of the three-mile section of Route 10 on new location as compared to the cost of reconstruction on existing location, the proposed dam would not adversely affect the existing highway network.

Sincerely yours,

G. D. Love
Division Engineer

EXHIBIT NO. F-8

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
NORTHEAST REGION
143 SOUTH THIRD STREET
PHILADELPHIA, PA. 19106

IN REPLY REFER TO:

L7423
NER(CF)

JUN 9 1965

Your reference:
NEDED-D

Division Engineer
Corps of Engineers
U.S. Army Engineer Division, New England
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Sir:

This is in reference to your letter of April 26 concerning the proposed Beaver Brook project, Keene, New Hampshire.

In view of the continued interest of the City of Keene in the Beaver Brook multi-purpose water control project, the opportunity to reassess our comments of March 1962 in the light of changed project design is appreciated.

We note that present plans provide for a recreation pool of 200 acres at elevation 811.0 and that waters could inundate a possible 310 acres at flood stage.

The impoundment, although small, will be located in a scenic setting. In general, its shore-to-water relationship is not conducive to most types of recreation development but can be expected to provide opportunities for picnicking, camping, fishing and boating in a scenic outdoor environment. The recreation potential is of local significance and would complement the use provided for at Otter Brook Dam State Park.

It is suggested that the area shown on the preliminary reservoir plan accompanying your letter of April 26 be extended 2,000 feet southerly to include a total of 4,000 feet of shoreline and the width broadened to an average depth of 800 feet back from the shore.

It is assumed that the indicated interest of the City Council of Keene embraces a desire to include administration of a Beaver Brook project's recreational potential as part of the park and recreation functions of the City of Keene. It would, therefore, be most appropriate that a recreation development plan be worked out in cooperation with the City of Keene and the New Hampshire Forestry and Recreational Department to insure coordination of a statewide plan.

Sincerely yours,

Ronald F. Lee
Regional Director

EXHIBIT NO. F-9
Page 2 of 2

NEDED-D 11 June 1965

Mr. A. C. Addison, State Conservationist
U. S. Department of Agriculture
Soil Conservation Service
Federal Building
Durham, New Hampshire

Dear Mr. Addison:

I am writing you regarding your letter of 13 May 1965 to General Ploger concerning our studies of the multiple-purpose Beaver Brook Dam and Reservoir at Keene, New Hampshire, which was in further reference to our communication of 26 April 1965. You requested a copy of the draft of the report, or other information upon which to make an evaluation or comment.

The Beaver Brook project has been in the study phase for sometime. You may recall that you attended the public hearing on 7 February 1962. Recently, the City Council approved a resolution requesting that this office submit a survey report for the subject project which had, in the interim period, been studied under the authority of Section 205, Public Law 874, 87th Congress. The City Council's action was the final step in arriving at a mutually agreeable plan of development.

The project is similar to the one reported to your predecessor, Mr. Kenneth E. Grant, in our letter of 25 January 1962, except for the inclusion of recreation as a project purpose. The Beaver Brook Dam will have no adverse effect upon the completed drainage projects in the Ash Swamp Watershed. In letter of 1 February 1962, your office reported that there were no existing plans to work in the watershed.

Local interests requested that we expedite our planning in a hope that the survey report might be part of the up-coming Omnibus Bill. As requested, we have attached, for your convenience, a copy of the draft of the survey report. The report is scheduled for submission about 1 July pending receipt of comments from other coordinating agencies.

Mr. A. C. Addison

11 June 1965

The report draft is nearly complete, but subject to final adjustments. I believe it will afford you with sufficient information upon which to make your comments.

It is requested that your views be dispatched as soon as possible.

Sincerely yours,

3 Incl
1. Draft of Report
2. General Plan
3. Reservoir Map

JOHN Wm. LESLIE
Chief, Engineering Division

EXHIBIT NO. F-10
Page 2 of 2

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Federal Building
Durham, New Hampshire 03824
June 23, 1965

Brigadier General Robert P. Ploger
New England Division Engineer
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts

Attention: Mr. John W. Leslie, Chief, Engineering Division.

Dear General Ploger:

This is in reply to your letter of June 11, 1965, requesting comments on the draft report of the Beaver Brook Project in Keene, New Hampshire.

We note from the report that the multiple-purpose dam and reservoir will include flood control, a permanent pool for recreational purposes, and minimum provisions for future water supply. The dam will control a drainage area of six square miles and will provide a permanent pool of 203 acres. The report also states that the total cost for this project is $1,960,000 with $1,670,000 being Federal funds and $290,000 local funds.

The cost-sharing arrangement provides that local funds bear one-half the separable cost allocated to recreation, plus the specific costs allocated to future water supply. This is consistent with procedures in Public Law 566 under which the Soil Conservation Service carries out its Small Watersheds Program.

I would like to point out that the Soil Conservation Service is very much interested in land treatment work in the Beaver Brook Watershed. In cooperation with the Cheshire County Soil Conservation District, soil and water conservation practices are being carried out with individual landowners in the watershed. These practices will increase infiltration rates and reduce soil erosion in the watershed. This will in turn reduce sediment yields into the reservoir and enhance the value of the water for recreation and fish and wildlife purposes.

We would refer you to two statements in Section X, paragraph 36, in reference to the Ash Swamp Project carried out under Public Law 566:

> "An important objective of the project was land reclamation by drainage. Incidental flood control benefits accrue to the project through the removal of surface water from precipitation by the system of channels."

These statements are incorrect, and we request that they be deleted from the report as the Ash Swamp was not a land reclamation project. We would refer you to pages 19 and 20 of the Watershed Work Plan for the Ash Swamp, Tannery, White and Black Brooks, which was transmitted to you on November 27, 1957. The work plan states that fifty percent of the benefits are allocated to flood prevention and fifty percent to agricultural and non-agricultural water management. Land treatment was also a very integral part of the plan, and the work planned for construction during the project installation period has now been completed. Additional land treatment work is still being carried out in the watershed in cooperation with the Cheshire County Soil Conservation District.

We agree that the Beaver Brook Project will not have any adverse effect on the Ash Swamp Project. However, we would like to point out that backwater from the Ashuelot River backs into some of the channels during periods when the release rate from the Surrey Mountain Dam is held at near bank full stage. This results in poor drainage in the lower reaches of the Ash Swamp Project during these periods of prolonged high release from Surrey Mountain Dam.

The Soil Conservation Service is most anxious to coordinate its activities in New Hampshire with the activities of the Corps of Engineers, and would be interested in attending meetings and hearings on projects of mutual concern both from the standpoint of projects in New Hampshire and those in the Connecticut River Basin with which we have added responsibilities. We would certainly be glad to attend meetings of the type held on March 22 and April 7, 1965, if invited to do so.

We certainly appreciate the opportunity to review the draft report on the Beaver Brook Project, and hope that our comments will be helpful to you in completing your final report.

Sincerely yours,

A. C. Addison

A. C. Addison
State Conservationist

UNITED STATES
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

Region I
John F. Kennedy Federal Building
Boston, Massachusetts 02203

June 23, 1966

Colonel Remi O. Renier
Acting Division Engineer
Corps of Engineers
U. S. Army Engineer Division
New England
424 Trapelo Road
Waltham, Massachusetts

Dear Colonel Renier:

This is in reply to your letter of 3 May 1966 in which you request our comments and evaluation of the revised survey report for the Beaver Brook Dam and Reservoir Project at Keene, New Hampshire.

The revised report proposes a local protection project consisting of a multipurpose dam and reservoir with a water control device in the upper reaches of the reservoir on Beaver Brook offering flood protection, recreation, fish and wildlife conservation and a future water supply for the City of Keene, New Hampshire. This dam, at the full flood control pool elevation of 822 ft. above mean sea level will create a reservoir about 2.5 miles long with a surface area of approximately 310 acres and will impound 5,750 acre-feet of water. The permanent pool will be maintained by a controlled outlet works and will have a surface area of 203 acres and a storage capacity of 3,000 acre-feet.

Beaver Brook is a relatively small tributary of the Ashuelot River, which is in turn, one of the principal tributaries of the Connecticut River. The Beaver Brook watershed encompasses 10 square miles, while the Ashuelot River drains 421 square miles at its mouth. At the proposed dam site, Beaver Brook has a watershed area of 5.98 square miles with an estimated average flow of 9 cfs. while the Ashuelot River at Surry Mountain Dam about 8 miles upstream from the City of Keene controls a watershed area of 101 square miles and has an average flow of about 180 cfs.

The City of Keene, New Hampshire with a present population of about 18,000 is the hub of cultural and economic activities in southwestern New Hampshire. It is located 15 miles north of the Massachusetts state

line and 15 miles east of Brattleboro, Vermont and the Connecticut River. The city is situated at the intersection of two north-south, and two east-west highways and is also served by Northeast Airlines, the Boston and Maine Railroad, and intercity bus lines. Numerous streams, including Ash Swamp, Tannery, Otter, and Beaver Brooks converge near Keene and contribute to flow in the Ashuelot River which flows through the center of the Keene business district.

Since the time of the first Keene, New Hampshire Census in the year 1790 when the population was 1,314, the population of the City of Keene and adjacent fringe areas has about doubled over each fifty- to sixty-year period. Between 1900 and 1940 the population increased from 9,165 to 13,832. Following World War II the population increased rapidly to 15,638 in 1950. By 1960 the population was 17,562.

Beaver Brook flows southward through the City of Keene and receives urban runoff from the city storm sewerage system. The waste treatment facilities of the City of Keene presently provide primary treatment and discharge to the Ashuelot River.

Comprehensive water resource investigations (Type 2) are currently being conducted in the Connecticut River Basin by personnel of this Administration in conjunction with the Corps of Engineers. Preliminary studies indicate that storage for water quality control purposes may be required along the Connecticut and Ashuelot rivers. The need for and value of this water quality control storage will be determined within the framework of the comprehensive investigations. A definitive recommendation on water quality control storage for the Beaver Brook Project will of necessity be dependent upon the results of these studies.

We have reviewed the municipal and industrial water supply needs of the city and believe additional water supply may be required in the future. Our review is based upon economic, demographic, and water use criteria developed for the Connecticut River Basin Comprehensive Water Resource Investigations. The engineering consultants for the City of Keene, Camp, Dresser and McKee, have reviewed past population trends and prepared estimates of future population as part of several public works projects. They estimate that the population of Keene will increase to about 31,000 by the year 2000 with about 85 percent of the increased population to reside in the relatively undeveloped area known as West Keene.

This estimate is believed to be reasonable in view of historical population trends as well as in consideration of current economic and population trends. In particular the Ash Swamp Project of the Soil Conservation Service and the Beaver Brook Project of the Corps of Engineers will

reduce flood problems and permit development of the West Keene area. In addition to the availability of land for development, new highways will provide better access for industrial development.

Since large water supply structures are generally designed for a project life of fifty years, a forecast of the future population of Keene was prepared. On the basis of an increase of approximately 3,400 persons per decade over the 1960 population of 17,562, it was estimated that the population of Keene will be about 34,000 persons in the year 2010.

The city presently satisfies its industrial and municipal water supply needs from both ground and surface water sources. The existing system is capable of supplying 5.9 million gallons per day (mgd.) with 2.9 mgd. supplied from Babbidge Reservoir and 3.0 mgd. from a well field in West Keene. In 1965 the city's daily water use averaged 3.2 mgd. with maximum daily consumptions of over 5 mgd. Presently, the per capita consumption is in the order of 118 gallons per capita per day (gcd.). With regard to the future, we estimate that the water supply demand will average 7.1 mgd. in the year 2010 with maximum daily consumption approaching 11 mgd. Per capita consumption will average about 210 gcd. Since the existing system currently supplies 5.9 mgd. and the current maximum daily demands exceed 5 mgd., it is apparent that additional water supply sources must be developed in order to support the anticipated growth of domestic and industrial water supply demands. Based on the information presented above, it is concluded that Keene will require the development of additional sources of water supply, one of which could be Beaver Brook Reservoir, providing an additional yield in the order of 4.0 mgd.

Sincerely yours,

Walter M. Newman

Walter M. Newman, Chief
Water Resources Development Activities
Federal Water Pollution Control
Administration

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
U. S. POST OFFICE AND COURTHOUSE
BOSTON, MASSACHUSETTS 02109

September 3, 1965

Division Engineer
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Sir:

This letter constitutes our conservation and development report on the fish and wildlife resources related to the multiple-purpose Beaver Brook Dam and Reservoir project on Beaver Brook in the Towns of Keene and Gilsum, Cheshire County, New Hampshire. Your study is being made under authority contained in the October 1960 Resolution of the Senate Committee on Public Works. This report was prepared under the authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661-666 inc.), in cooperation with the New Hampshire Fish and Game Department. That agency has indicated its concurrence by letter dated September 1, 1965. A preliminary report on fish and wildlife resources related to the now defunct Beaver Brook local flood protection project was released in May 1962.

We understand that this is a multiple-purpose project for flood control and recreation. We are also aware of the possibility that water supply for the City of Keene, New Hampshire, may become a primary function of the reservoir in approximately 20 years.

The dam would be located about two miles from the City of Keene and approximately 1,100 feet upstream from new Route 9. It would consist of a rolled-earth structure with rock slope protection and a concrete chute-type spillway. The dam would be about 53 feet high and control a drainage area of six square miles. At spillway crest elevation 822 1/ the flood control pool would have a surface area of 310 acres. This pool would periodically inundate about 0.7 mile of Beaver Brook. The recreation

1/ All elevations are in feet and refer to mean sea level datum.

and/or water supply pool at elevation 811 would have a surface area of 200 acres. This pool would permanently inundate two miles of Beaver Brook (plate I). Relocated Highway No. 10 will cross the reservoir a short distance south of the Keene-Gilsum town line.

Reservoir operational procedures would be to control all floods to the maximum extent possible and to evacuate flood waters as rapidly as downstream conditions permit. Normal stream flow would pass through an intake tower with bottom conduit. During periods of low flow, reservoir outflow would be calibrated to equal reservoir inflow. The proposed recreation pool would be held as constant as practical at elevation 811. No drawdown data are available for the water supply pool which may supplant the recreation pool in about 20 years.

We understand that a major recreation area, including facilities for picnicking, swimming, and boating, is being planned for the upper western section of the reservoir. It is assumed that lands will be purchased in fee title to the maximum flood control pool elevation, plus an allowance for "blocking out". Reservoir clearing plans are not known at this time.

The lands and waters within the area of project influence support moderate quality fish and wildlife resources of local significance. These resources are predominantly associated with a 25-acre wetland within the lower reaches of the proposed reservoir.

Beaver Brook, upstream from the project area, has been occasionally stocked with trout. Within the project area the principal fish species are chain pickerel and brown bullhead. Downstream from the project the brook does not support a significant fishery. Current utilization of the fishery resource within the project area is low. It is estimated that average annual fisherman utilization of this resource over the 50-year period of analysis will be 150 man-days.

The 25-acre wetland, most of which is the bed of an old shallow mill pond, maintains a small breeding population of wood ducks and black ducks. These waterfowl generate the major hunting interest. Grouse, woodcock, hare, and deer utilize the reservoir area and contribute to the diversity of hunting opportunity. Fur animals such as muskrat, mink, otter, and beaver, though present, constitute a resource of minor value. During the period of analysis, the average annual hunter-utilization of deer, upland game, and waterfowl resources in the reservoir area are estimated to be 40, 60, and 50 hunter-days, respectively.

Construction of the Beaver Brook Dam will create a 200-acre reservoir with suitable fishery habitat for predominantly

warm-water species. Reservoir fishery resources will consist primarily of chain pickerel, brown bullhead, and largemouth bass. A possibility exists for establishment of a marginal brown trout fishery. Downstream conditions will not be sufficiently altered to create a significant fishery. During the period of analysis, the average annual utilization of the reservoir fishery is estimated to be 3,750 fisherman-days for the recreation pool. If the reservoir becomes a water supply, the present policy of the City of Keene which prohibits recreational use of water supply reservoirs may prevail. Should this occur, the average annual utilization will be only 950 fisherman-days over the period of analysis.

Benefits accruing to the fishery resource will be 3,600 fisherman-days if the reservoir remains open to fishing throughout the period of analysis, but only 800 fisherman-days if fishing is prohibited should a water supply be involved. These represent net recreational values of $3,600 and $800 respectively.

Table 1. Average Annual Fishery Utilization and Values 1/

Plan	Without-the-Project		With-the-Project		Net Gain	
	Man-Days	$ Value	Man-Days	$ Value	Man-Days	Value
Recreation 2/	150	150	3,750	3,750	3,600	3,600
Water Supply	150	150	950	950	800	800

1/ Evaluation based on 50-year project life.
2/ With-the-project values applicable if in about 20 years fishing should be prohibited for remainder of project life.

The reservoir will permanently inundate 200 acres of wildlife habitat including the productive 25-acre wetland area. No benefits will accrue to the waterfowl resource since only a token number of birds is expected to utilize the area. Stabilization of the recreation pool will have little effect on the fur resource. During the period of analysis, all hunting opportunities amounting to 150 hunter-days are expected to be eliminated from the reservoir area.

In discussions with your staff concerning a method whereby the lost wildlife resources could be mitigated, it was concluded that the most satisfactory solution would be the construction of a dike near the upper reach of the flood pool. This dike would create a subimpoundment of 50 acres that could be managed for waterfowl. The outlet structure would contain stoplogs to permit water level manipulations from elevation 822 to 828. As part of the wildlife loss compensation, a boat launching ramp and half-acre parking area should be provided for hunters at the subimpoundment. We have been advised by your staff that the dike and access facilities will cost approximately $15,000. Construction and maintenance of the mitigation facilities should be funded as nonreimbursable Federal project costs.

The subimpoundment area should not be included in the general reservoir clearing plan. A minor incidental pickerel and bullhead fishery may become established in the subimpoundment. The lands and waters of the subimpoundment should be made available to the New Hampshire Fish and Game Department for administration under a General Plan for Fish and Wildlife Management pursuant to the provisions of the Fish and Wildlife Coordination Act.

We understand that present Route 10 will serve as an access road to the main reservoir recreation area. Recreation plans should include a boat launching ramp coupled with a one-acre parking lot for fishermen access to the Beaver Brook Reservoir.

The New Hampshire Fish and Game Department will stock appropriate fish species in Beaver Brook Reservoir and assume management of the fishery resource as far as deemed practical.

As detailed project data become available, subsequent to project authorization this Bureau will wish to review the Corps' plans regarding project zoning, public access, timber clearing, subimpoundment dike, and other features to assist in development of a plan that gives adequate consideration to fish and wildlife resources and their utilization.

We recommend:--

1. That project-occasioned wildlife resources losses be mitigated by constructing a dike near the upper reach of the flood pool to create a shallow subimpoundment essentially as described in this report, construction and maintenance costs to be funded as nonreimbursable project costs.

2. That recreational plans include a boat ramp and 1-acre parking area at the reservoir, and a one-half-acre parking area and boat ramp at the subimpoundment.

3. That fishing be encouraged in the reservoir even though it may be used for domestic water supply.

4. That the subimpoundment be excluded from the general reservoir clearing plan.

5. That the lands and waters of the subimpoundment be made available for administration by the New Hampshire Fish and Game Department under a General Plan for Fish and Wildlife Management pursuant to provisions of the Fish and Wildlife Coordination Act.

6. That the report of the Corps of Engineers include language recommending that additional detailed studies of fish and

wildlife resources be conducted, as necessary, after the project is authorized, in accordance with the Fish and Wildlife Coordination Act, and that such reasonable modifications be made in authorized project facilities, or operations, as may be agreed upon by the Director, Bureau of Sport Fisheries and Wildlife, the Chief of Engineers and the Director of the New Hampshire Fish and Game Department for the conservation, improvement and development of these resources.

Sincerely yours,

Eugene E. Crawford

Acting Regional Director

CITY OF KEENE

IN THE YEAR OF OUR LORD ONE THOUSAND NINE HUNDRED Sixty-Six

A RESOLUTION relating to Beaver Brook Dam

Resolved by the City Council of the City of Keene, as follows:

Whereas the City of Keene desires to control the flood damage caused by the Beaver Brook, and

Whereas the U.S. Army Corps of Engineers has submitted a preliminary plan for a multi-purpose flood control-water supply-recreation facility on Beaver Brook, and,

Whereas the Corps plan provides preliminary information indicating the feasibility of this project--tentative financing as follows:

Corps of Engineers Flood Control Grant	$396,000
Corps of Engineers Recreation Grant	261,500
Corps of Engineers Long-term Note--Water	266,000
Corps of Engineers Long-term Note--Recreation	51,500
City of Keene	102,500
State of New Hampshire Grant	102,500
Bureau of Public Roads -State of N.H. Highway Relocation	727,000
Total Project	$1,907,000

Whereas it is necessary for the City of Keene to agree to certain requirements of the project, namely,

1) Provide land, easements, and relocations for the project.
2) Hold U.S. Government harmless from damages.
3) Maintain and operate project after completion.
4) Prevent future encroachment on flood control function.
5) Pay for certain non-flood control costs.

Whereas the water supply feature of the dam is of substantial benefit to the City, providing water supply capacity equal to the present City system.

Whereas the recreation lake of 203 acres will be of considerable benefit to the City of Keene in its development as a center for New England water sports and relaxation.

Now therefore be it resolved by the City of Keene as follows:

1) The City of Keene urges the approval of this project as outlined above by the United States Government, and hopes for its expeditious handling by Congress.
2) The City of Keene agrees to the general preliminary cost outline and conditions set forth in the preamble, and
3) The City of Keene pledges its cooperation in all ways with the Corps of Engineers and other governmental agencies to make this much-needed project a reality.

Richard E. Bacon
Mayor

PASSED April 21 1966

A true copy
Attest: Betty A. Knight
City Clerk

EXHIBIT NO. F-14

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
U. S. POST OFFICE AND COURTHOUSE
BOSTON, MASSACHUSETTS 02109

May 11, 1966

Division Engineer
U.S.Army Engineer Division, New England
Corps of Engineers
424 Trapelo Road
Waltham, Mass. 02154

Dear Sir:

Thank you for your letter of May 6, 1966 concerning the status of the Beaver Brook Dam & Reservoir project at Keene, New Hampshire.

We appreciate your consideration in keeping us advised on the development of the project.

Sincerely yours,

Richard E. Griffith

Regional Director

EXHIBIT NO. F-15

Federal Building
Durham, New Hampshire 03824

May 17, 1966

Colonel Remi O. Renier
Acting Division Engineer
U. S. Army Engineer Division, New England
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Renier:

Receipt is acknowledged of your letter of 6 May 1966 concerning the status of the Beaver Brook Dam and Reservoir Project at Keene, New Hampshire.

We very much appreciate your keeping us informed of such projects.

Sincerely yours,

A. C. Addison
State Conservationist

ACAddison;AWC
May 17, 1966

cc
L. J. Peet

EXHIBIT NO. F-16

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
NORTHEAST REGION
143 SOUTH THIRD STREET
PHILADELPHIA, PA. 19106

NATIONAL PARK SERVICE 1916 1966 50TH ANNIVERSARY

IN REPLY REFER TO:
L7423
NER(OM)

MAY 23 1966

Your reference:
NEDED-D

Lt. Colonel W. H. Kastner
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Kastner:

We sincerely appreciate your thorough letter of May 6 detailing the status of the Beaver Brook Dam and Reservoir Project at Keene, New Hampshire.

We shall continue to follow with great interest your future reports of the development of this latest multiple purpose project designed to further promote conservation, recreation and flood control in the Northeast.

Sincerely yours,

George A. Palmer
Acting Regional Director

EXHIBIT NO. F-17

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF OUTDOOR RECREATION
128 N. BROAD STREET
PHILADELPHIA, PENNSYLVANIA 19102

Your ref:
NEDED-E

IN REPLY REFER TO:
D64

February 27, 1967

Division Engineer
Corps of Engineers, New England Division
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Renier:

In reply to Mr. Leslie's February 13, 1967 request for our comments and evaluation of the recreational aspects of the proposed project on Beaver Brook, Keene, New Hampshire, and within the authority contained in the Bureau's Organic Act of 1963 (77 Stat. 49) and the Federal Water Project Recreation Act (79 Stat. 213), we offer the following:

We have reviewed the revised Survey Report dated December 1966 giving particular attention to Appendix E, Recreation, and are in general agreement with your findings, conclusions and recommendations.

We understand that the reservoir will provide storage for flood control, general recreation, fish and wildlife conservation, and future water supply at an estimated total first cost of $1,907,000, with the Federal first cost estimated at $883,500 and the non-Federal at $1,023,500. Non-federal participation to include the provision of all lands, easements and rights-of-way and operation and maintenance of the completed project in accordance with the 1936 Flood Control Act, as amended; the Federal Water Project Recreation Act; and the Water Supply Act of 1958, as amended.

Your estimated initial costs of $103,000 for recreation development and total annual costs of $8,900 appear reasonable to us. In view of the proposed project's relatively small size, 200 acres for water-based recreational activities, its proximate location to Keene, New Hampshire and several other population centers, and the limiting aspects of the surrounding topography, we concur with your plan to develop primarily a day use area for an estimated annual visitation of 53,600 which includes 3,600 man days of fishing as estimated by the Fish and Wildlife Service. We also consider your estimate of equivalent average annual benefits of $32,000, considering the periods with and without water supply, to be logical and in accordance with established procedures.

EXHIBIT NO. F-18
Page 1 of 2

Your recreational development plan is further supported by New Hampshire's current Comprehensive Outdoor Recreation Plan, and the Connecticut River Basin Comprehensive Study, which indicates a significant need for additional water-oriented recreational development in the area.

We do have a question regarding the location of a pit type toilet at approximately elevation 817 which is within the flow line of spillway crest, elevation 822, as shown on the development plan, Plate No. E-1. Since the reservoir may be used for a water supply some 20 years following construction, we believe consideration should be given to relocation of this facility when general design memoranda are formulated. We feel this may prove to be an important consideration if and when the reservoir is used for water supply. Although current state policy limits recreational use of water supply reservoirs, this may not always be the case in face of increasing public pressure to fully utilize the resource. In our opinion, the presence of a pit type toilet within the spillway crest flowline could have a bearing on the decision to use the reservoir for a water supply either with or without restricted recreational use.

We recommend:

1. That full recreational use be encouraged if and when the reservoir is used for water supply.

2. That sanitary facilities be located above areas which would be periodically inundated.

3. That acquisition include the area between the reservoir and the proposed relocation of Route 10.

4. That boating be restricted to small boats with limited horsepower, in order to avoid conflict with fishing, swimming, and other recreational uses on this relatively small facility.

We appreciate this opportunity to comment on your revised Survey Report.

Sincerely yours,

Rolland B. Handley
Regional Director

EXHIBIT NO. F-18
Page 2 of 2

ATTACHMENTS

ATTACHMENT I

DIGEST OF PUBLIC HEARING

1. This attachment presents a digest of the public hearing held at Keene, New Hampshire, on 7 February 1962, Hearing Officer, Lt. Colonel Uriah N. Orr. The purpose of the hearing was to ascertain the needs and desires for flood control and allied purposes on Beaver Brook at and in the vicinity of Keene.

2. The attachment contains a digest of statements by state and local officials and other interested parties, and also of letters submitted at the hearing.

DIGEST OF PUBLIC HEARING 7 FEBRUARY 1962

Speaker	Interest Represented	Improvement Desired	Reasons Advanced and Other Remarks
Mr. James B. Miskelly	U. S. Senator Maurice J. Murphy, Jr.		Citizen of Keene and familiar with problem of Beaver Br. flooding. As official delegate of U. S. Senator Murphy, interested in official proceedings of meeting.
Mr. Walter G. White, Chairman	New Hampshire Water Resources Board		Aware of Keene's long history of flood damage, the Board stands ready to cooperate with any agency in helping to bring about additional flood protection.
Mr. Robert Whitaker, Deputy Chairman	New Hampshire Department of Public Works and Highways		The Department looks with favor on a (flood control) project on Beaver Brook. They stand ready to cooperate, and have already done so by deferring their relocation of Route 10 in the reservoir area in order to coordinate with the flood control studies.
Mr. Jonathan Pollard	New Hampshire Planning and Development Comm.		The Commission offers its services to coordinate local and state plans for future use of the reservoir.
Mr. Donald Chick, City Manager	City of Keene	Suggestions for study: a. Flood control dam & res. b. Channel improvement of Beaver Br. through Keene. c. Diversion of Beaver Brook. d. Dredging of Ashuelot River. e. Modification of dam at West Swanzey.	There would be downstream benefits from a (dam) project on Beaver Brook, although diversion would not help downstream. The City of Keene is plagued with drainage problems, and high water causes backup and leakage in both the sanitary and storm water drains. Some people think that nothing can be done without controlling the level of the Ashuelot. Mr. Chick thinks that a multi-purpose flood control project would stretch the Federal dollar to the maximum degree.
Mr. Robert Shaw, City Engineer	City of Keene	Flood Control Project	Major floods (in Beaver Brook) can be caused by a 2.5 inch rainfall, and occur at 5 to 10-year intervals. Minor flooding occurs annually. The Corps damage estimate for the 1960 flood is perhaps conservative.

Speaker	Interest Represented	Improvement Desired	Reasons Advanced and Other Remarks
Mr. Darrell Root, Partner: Camp, Dresser & McKee	Consultants to City of Keene	Alternative measures: a. Flood control dam. b. Lowering level of Ashuelot. c. Channel improvement.	There are serious drainage problems in the Beaver Brook flood plain. For improvement of drainage, the water level in Beaver Brook must be lowered. If there is any possible way to utilize and incorporate water supply facilities within the proposed dam, it should be made definitely a part of that study.
Mr. J. F. Burke, Public Works Superintendent	City of Keene	Flood Control Project	Streets over Beaver Brook sometimes have to be closed off for as much as 15 days during high water. This creates a problem in sanitary facilities, in which the U. S. Public Health Service may take an interest. The demand for sewage treatment during high water exceeds the capacity of the plant. Damages are not limited to the flooded areas, since extra municipal expenses are paid by the taxpayers at large.
Mr. Don Cook, Councilman	Ward 1, Keene	Flood Control Project	We have a problem that the City of Keene cannot solve without the help of the Federal Government. I have seen a matter of four or five thousand dollars put into the budget for riprap and walls and then seen the walls washed out through the next storm. Within a half mile of Beaver Brook, we have the biggest concentration of taxable property in the City of Keene. We had a problem out in West Keene with drainage and we solved it. We have a bigger problem here...and the only way we can do it is cooperate with the Federal Government and get on the ball now.
Mr. William E. Arnold, City Health Officer	Department of Health, Keene	Flood Control Project	I would like to go on record in regard to the public health situation of the backup into the sanitary sewer lines. It is a very serious problem and if this (project) will take care of it, it is a very worthy consideration.

Speaker	Interest Represented	Improvement Desired	Reasons Advanced and Other Remarks
Mr. Robert L. Mallat, Mayor	City of Keene	Possible solutions to flood problem: a. Flood control dam. b. Channel improvement in the Ashuelot River. c. Diversion of Beaver Brook. d. A combination of all or parts of the above.	Two major problems in Keene: (1) flooding of residential and industrial areas, and: (2) disruption of storm and sanitary sewer facilities. The condition has become increasingly worse. A solution must be forthcoming before any improvement can be made in the whole area. The City feels that there are benefits to be gained, not only directly below the proposed dam but also in the areas to the south of New Hampshire.
Mr. Edward P. Nolin, President	Beaver Brook Association	Flood Control Project	$2,516,000 worth of property between Beaver and Water Streets subject to flooding. 285 people signed the original request for action. The flooding has become worse and more frequent since the 1938 flood. In view of the State road building program, and the fact that a part of the City is flooded out about every three years, there should be no further delay in flood control.
Letters from 59 property owners	Beaver Brook Association and selves	Flood Control Project	Damages. Deterred from improving Health hazard from sewage. Inconveniences and hardship. Business and personal losses. Depreciation of values.
Mr. Edward Ellingwood, Executive Vice-President	Industrial Foundation (of Keene)	Flood Control Project	The Foundation is definitely in support of some type of correction of the flooding situation. We are not here to complain or criticise, but to back up what we think the Corps will recommend for this correction.
Mr. Eli Court	Keene Wood Heel Co.	Flood Control Project	High scare costs (sandbags, etc.). In 1960, toilets could not be used for three days. Water level came in on the floor. If it had been one-foot higher, the motors that run the lathes would have been lost, as they were in 1938. Something should be done.
Mr. Arthur English, General Manager	Abbott Company (Juvenile Furniture)	Flood Control Project	Had quite a bit of damage in the 1960 flood. Heavy machinery and inventories, on ground floor, have had to be moved twice. Hopes that some solution can be found.

Speaker	Interest Represented	Improvement Desired	Reasons Advanced and Other Remarks
Mr. Chester Kingsbury	Kingsbury Machine Tool Corporation	Flood Control Project	Heavy damages in 1936. Channel improvement and dikes built. While the Surry Mountain and Otter Brook Dams have helped the situation, it is still the volume of water that flows in Beaver Brook that causes the trouble in the eastern part of the city and remains a serious and potential danger until some correction is made.
Mr. Fred Daley	Dalbolt Co. (printing)	Flood Control Project	Heavy preventive expenses. This is certainly a project that we deem most important.
Mr. Franklin Carey, Treasurer	Carey Chair Manufacturing Company	Flood Control Project	During any high waters, we have experienced consistently a backing up of the sewers into our facilities and this can last from two, three or four days. Therefore, we are very much in favor of a solution to the problem of the flooding of Beaver Brook.
Mr. Otto E. Reuter	Henkel Company	Flood Control Project	In past years, the water has come dangerously close and perhaps the matter of an inch might have caused damage in the factory. We are in favor of having any improvements that could be done in the direction outlined at this meeting so far.
Mr. Fred Hickok, President	Cheshire County Savings Bank	Flood Control Dam	The trustees strongly favor the building of a flood control dam and reservoir to control the Beaver Brook situation. Signs of increasing blight caused by flooding conditions which make homeowners unwilling or unable to correct the situation.
Mr. John Sias, Managing Director	Greater Keene Chamber of Commerce	Flood Control Dam	By vote of the Executive Committee and President, Robert D. Clark, Jr., this economic development organization, representing the active interests of 280 business and professional organizations, goes on record as actively supporting the proposed dam on Beaver Brook.

Speaker	Interest Represented	Improvement Desired	Reasons Advanced and Other Remarks
	Greater Keene Chamber of Commerce (Cont'd)		The Chamber believes the ratio of cost to savings warrants the construction of this dam. The Chamber believes the proposed dam will result in economic protection of homes and businesses in the areas served by the dam. The Chamber also believes this dam will do much to control health and sanitation problems resulting from the periodic flooding of the area, the most populous in the city. The Chamber also expects this dam will do much to preserve employment in those businesses usually affected by flooding. From both the points of economic and human values, the Chamber believes the proposed dam should be constructed.
Mr. Whelan Dunn, Treasurer	Keene Cooperative Bank	Flood Control Project	"The Keene Cooperative Bank wishes to go on record as being in favor of any action which can be taken to control Beaver Brook and the damage caused by its flooding. Our investment in the area affected by Beaver Brook consists of 22 mortgages totalling $131,321.40 and is low in comparison to our investment in other areas. It is the result, however, of our reluctance to invest in an area where unfavorable conditions exist, which can cause property damage, loss of value and make the disposition of real estate more difficult. We believe, therefore, that the control of Beaver Brook is absolutely necessary, that is is in the best interests of the people and that it will aid in the economic development of the area." (Letter from Roland L. Harper, Executive Vice-President).
Mrs. Mary Hulslander	Husband's Plumbing and Heating Firm	Flood Control Project	We have seen what this flooding does in the homes in Keene - to their heating and plumbing, and we would like to go on record as hoping that something will be done for the people.

Speaker	Interest Represented	Improvement Desired	Reasons Advanced and Other Remarks
Mr. R. L. Champagne, Principal	Simon School	Flood Control Project	Has seen youngsters wading in (flood) water up to their armpits, has seen them drinking the water. Would like to go on record favoring (Corps) disposition on this project.
Mr. Michael Blastos	James Tasoulas Realty & Market, Inc.	Flood Control Project	Primarily concerned about tenants, the heating conditions that are eliminated with flooding, and the sanitary conditions which are prevailing whenever there is flooding. Would like to go on record as backing this (project) one hundred per cent.
Mr.Thomas Blake	Self and Family	Flood Control Dam	I believe there is only one solution to the problem we are concerned with in the Beaver Brook flood plain, and that is the construction of the Beaver Brook flood control dam.
Mr. Jeremiah Keating	Store owner, Ward 1	Flood Control Project	Would like to go on record and be very much in favor of some situation being done in Ward 1. I run a store on the corner of Marlboro and Grove Streets. We deliver groceries in a boat. The water comes up across to the corner of the brook on Marlboro Street, but I sold my boat now and don't know what I would do if the water did come up there again.
Mr. Francis Callahan, Councilman	Ward 3	Flood Control Project	Wishes to go on record in favor of the project.
Mr. Gerard F. Russell City Councilman (by letter)	Ward 5	Flood Control Project	..."want to go on record as being very much in favor of the Beaver Brook Flood Control Project."
Mr. Robert F. Babcock (by letter)	Self	Flood Control Project	The writer has personally seen raw sewerage pouring out on several of our streets when Beaver Brook reaches flood stage. We are not certain what the tie-in is between the brook and our sewerage disposal system, but in any event it is a filthy mess and if the control of the water in Beaver Brook eliminates this source of almost any widespread disease in our community, it is urged that the project be completed.

Speaker	Interest Represented	Improvement Desired	Reasons Advanced and Other Remarks
Mr. Ronald P. Bach, President (by letter)	Keene Savings Bank	Flood Control Dam & Reservoir	"In connection with the public hearing to be held on February 7th in Keene respecting flood control on Beaver Brook please be advised that this Bank has the following real estate investment in the effective area: ... The total assessed valuation of these properties is $195,150. We have become increasingly concerned over the flooding of Beaver Brook; that sanitary conditions in the area at the time of flooding constitutes a menace to the health of the community; that as we go about appraising real estate in the area for the purpose of making mortgages we can see progressive evidence of blight. Therefore, we favor building a flood control dam and reservoir; in fact it is imperative that this step be taken for the good of the community."
Mr. John W. Panek	Self	Flood Control Dam	Please cast my vote in favor of the proposed Beaver Brook Dam in Keene, New Hampshire.
Mr. Richard Bean, President (by letter)	R. E. Bean Construction Company, Inc.	Flood Control Project	"We are in wholehearted support of any project that will definitely aid the area from flooding, and therefore aid in its sanitation.
Mr. John R. Holbrook	John R. Holbrook Associates	Flood Control Dam	"A flood control dam on Beaver Brook is strongly recommended by this office."
Edward P. Nolin, President	Beaver Brook Association	Flood Control Project	The following petition was presented to the Mayor and City Council, April 1960. To the Honorable Mayor and City Council: The following residents of the City of Keene, hereby petition for necessary improvements to the drainage system of Beaver Brook and to the sanitary sewer system of the City of Keene, to alleviate the flooding of streets and property and the overflowing of sewers along Beaver Brook and adjacent areas. (Following are the signatures of 285 Taxpayers and property owners who signed the above appeal)".

ATTACHMENT II

BEAVER BROOK DAM AND RESERVOIR
BEAVER BROOK, ASHUELOT RIVER
KEENE, NEW HAMPSHIRE

Information Called for by
Senate Resolution 148, 85th Congress, 1st Session
Adopted 28 January 1958

ATTACHMENT II

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INTERIM REPORT ON REVIEW OF SURVEY

BEAVER BROOK, ASHUELOT RIVER,

KEENE, NEW HAMPSHIRE

NOVEMBER 1966

ADDITIONAL INFORMATION ON RECOMMENDED AND ALTERNATIVE PROJECTS CALLED FOR BY SENATE RESOLUTION 148, 85th CONGRESS, ADOPTED 28 January 1948

1. PROJECT DESCRIPTION AND ECONOMIC LIFE

The recommended dam and reservoir project would be located about 2.5 miles north of the center of Keene, New Hampshire, and 1,100 feet upstream from where New Hampshire State Route No. 9 crosses Beaver Brook. The project, which would protect residential, commercial and industrial property in Keene and also reduce stages in the downstream flood plains of the Ashuelot and Connecticut Rivers, provides a permanent pool for recreation, fish and wildlife conservation, and future water supply. The plan of improvement includes the relocation of New Hampshire State Route No. 10; utilities consisting of telephone and electric power lines along Route 10; a 115 kv transmission line which crosses the reservoir area about 1,200 feet upstream of the dam will be relocated south of the dam site; the construction of an earth dam, concrete spillway, and outlet works; minimum provisions for conversion to water supply; and a recreation facility area for bathing, boating, fishing and picnicking. Alternative methods of protection, such as channel improvements, channel relocations and modification of existing dams have been given preliminary study. These plans were found to be either more costly than the recommended plan or impractical. A complete description of the recommended plan is given in Section XIII of the main report and in Appendix C.

The proposed project has been evaluated on the basis of a 100-year economic life, however, Table 1 of this attachment shows a comparison of 50 and 100-year economic life.

2. PROJECT COSTS

The estimates of first costs and annual charges have been prepared on the basis that local interests would provide the assurances and non-Federal costs and reimbursements recommended in Section XXI of the main report.

Project first costs are based on average bid prices for similar work in the same general area, adjusted to 1966 price levels. Annual charges in the report are based on interest on the investment and amortization over the assumed project life, to which are added amounts for maintenance and operation of the project and interim replacement costs of equipment having an estimated life of less than the economic life. Interest rates are 3.125 percent for Federal and non-Federal costs. First costs and annual charges are summarized in Table 2 of the main report and detailed in Table No. C-2 of Appendix C.

3. PROJECT BENEFITS

Average annual benefits that would be realized from the recommended project are $113,600 for flood control, $32,000 for recreation, and $20,100 for water supply. Flood control benefits in the Ashuelot River Basin for the Beaver Brook Dam are taken as acting next after Surry Mountain and Otter Brook Reservoirs. To determine the average annual water supply benefits which would accrue to the recommended reservoir, the annual charges for the alternative single-purpose water supply reservoir were discounted to reflect the estimated period before water supply would first be used after completion of the project. The average annual recreation benefits were discounted to reflect the preclusion of water contact activities when the reservoir is utilized for water supply. Table No. C-7 in Appendix C gives a summary of benefits and benefit-cost ratios for the recommended project and for each of the project purposes included.

Intangible benefits, including prevention of loss of life, prevention of disease caused by flooding of polluted water, elimination of the need for emergency evacuation measures and the stabilizing effect on community life in the valley would also be realized from the construction of the Beaver Brook Project.

4. BENEFIT-COST RATIOS

Table 1 presents a comparison of project costs and benefits for the Beaver Brook project. The ratio of annual benefits to annual costs is given for both a 50 and 100-year project life.

R 3/6/67

Benefits are based on tangible benefits as given in Paragraphs 52 to 56 of the main report. Annual costs consisting of interest on investment, amortization and maintenance and operation and allowance for major replacement costs, are reported in Paragraphs 50 and 51 of the report. The benefit-cost ratio for the plan of a 100-year project life is substantially the same for each of the three methods of cost allocation used, and the same holds true of the plan for a 50-year project life. The benefit-cost ratio for the 100-year project life is significantly greater than that of the 50-year project life.

5. PHYSICAL FEASIBILITY AND COST OF PROVIDING FOR FUTURE NEEDS

All foreseeable future needs have been considered in formulating the project. The recommended improvement will reduce flood flows on Beaver Brook downstream of the dam site to its confluence with the Ashuelot River and provide substantial protection to presently flood prone property, as well as lower stages in the downstream flood plains of the Ashuelot and Connecticut Rivers. The project will also provide a permanent pool to be utilized for recreation purposes until such time as the need for additional water supply for the City of Keene becomes evident. Minimum provisions for water supply would be incorporated into the outlet structure of the dam at a cost presently estimated at $20,000.

Construction of a multiple-purpose dam and reservoir at the proposed site would help satisfy needs for recreation and future water supply in addition to flood control. Each need would be met more economically by this combination of purposes in one dam and reservoir than it would be by construction of a single purpose reservoir for that purpose.

Immediate needs for flood control and recreation, which are both physically and economically feasible, would be met by the construction of the Beaver Brook Dam and Reservoir. The conversion of the recreation pool to water supply storage would yield 4 million gallons per day and would meet a shortage expected to begin to materialize about 20 years after project completion. The inclusion of minimum provisions for future water supply in the outlet structure of the dam will preclude the construction of these works in the future at a substantially higher cost.

6. ALLOCATION OF COSTS

Allocation of costs for the project purposes of flood control, water supply and recreation were computed by (1) the separable cost-remaining benefits method, (2) the priority of use method, and (3) the incremental cost method for project economic lives of 50 and 100-years. The cost allocation summary is shown in Table No. 2.

7. EXTENT OF INTEREST IN PROJECT

The recommended plan received the approval of State and City officials and many of the local citizens at a public hearing and subsequent meetings. Copies of letters commenting on the project and abstracts of statements given at the hearing are contained in Appendix F and in Attachment I. Firm assurances of local participation would be obtained after authorization, but prior to initiation of construction.

8. REPAYMENT SCHEDULES

There are non-Federal costs and reimbursable features incorporated in the recommended plan. Any required cash contribution or reimbursement by non-Federal interests would be made in accordance with applicable Federal law.

Non-Federal costs consist of providing lands and utility and highway relocations necessary for the construction and operation of the project currently estimated at $402,000.

Payment for water supply is required of local interests on the basis that they would repay the United States for that portion of the construction costs allocated to water supply within the life of the project but in no event to exceed fifty years after the project is first used for the storage of water for water supply purposes, except that (1) no payment need be made with respect to storage for future water supply until such supply is first used, and (2) no interest shall be charged on such cost until such supply is first used, but in no case shall the interest-free period exceed ten years.

Payment of the cost allocated to water supply, currently estimated at $104,000 is a requirement of local participation in the recommended Beaver Brook Dam and Reservoir project. The water supply storage is not expected to be needed for about 20 years subsequent to project completion and, under the provisions of the Water Supply Act of 1958, as amended, the maximum allocated cost of storage for future use cannot exceed 30 percent of the total project investment. Local interests would also be required to pay the allocated annual costs of maintenance, operation, and major replacements, currently estimated at $1,800.

Under the provisions of H. R. 5269, 89th Congress, local interests would also have to bear not less than one-half the separable costs of the project allocated to recreation and fish

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and wildlife enhancement, an amount currently estimated at $51,500, and all the costs of operation, maintenance, and replacement of recreation and fish and wildlife enhancement lands and facilities, an amount currently estimated at $7,100 annually.

9. PROPOSED INCREASES IN APPROPRIATIONS

The recommended project would increase the necessary Federal appropriations required for the construction of flood control projects in the Connecticut River Basin by $819,500. The present basin-wide flood control plan for the Connecticut River, together with the status of each element, is given below.

Project	Present Status
Dams and Reservoirs	
Union Village, Vermont	Complete
North Hartland, Vermont	"
North Springfield, Vermont	"
Ball Mountain, Vermont	"
Townshend, Vermont	"
Surry Mt., New Hampshire	"
Otter Brook, New Hampshire	"
Birch Hill, Massachusetts	"
Tully, Massachusetts	"
Barre Falls, Massachusetts	"
Knightville, Massachusetts	"
Mad River, Connecticut	"
Littleville, Massachusetts	"
Conant Brook, Massachusetts	Under Const Complete
Colebrook River, Connecticut	" "
Sucker Brook, Connecticut	Under Design Completed
Claremont, New Hampshire	Being Restudied
Victory, Vermont	" "
Gaysville, Vermont	" "
The Island, Vermont	Deferred
Alt. for Sugar Hill, N.H.	Inactive
So. Tunbridge, Vermont	"
West Canaan, New Hampshire	"
Ludlow, Vermont	"
Brockway, Vermont	"
Cambridgeport, Vermont	"
Honey Hill, New Hampshire	"

21 Reservoirs
(14) Complete
(2) Under Const.
(4) Deferred (3 being restudied)
(7) Inactive

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Project	Present Status
Local Protection Projects	
Northampton, Massachusetts	Complete
Holyoke and Springdale, Massachusetts	"
Chicopee, Massachusetts	"
West Springfield and Riverdale, Massachusetts	"
Springfield, Massachusetts	"
East Hartford, Connecticut	"
Hartford, Connecticut	"
Weston, Vermont	"
Keene, New Hampshire	"
West Warren, Massachusetts	"
Winsted, Connecticut	"
Chicopee Falls, Massachusetts	"
Ware, Massachusetts	"
Gardner, Massachusetts	"
Three Rivers, Massachusetts	Under Constr
Westfield, Massachusetts	Under Design
Ludlow, Vermont	Inactive

10. EFFECT OF PROJECT ON STATE AND LOCAL GOVERNMENTS

The proposed improvements will necessitate the acquisition of about 730 acres of land in fee. Loss of taxes on land areas to be inundated by the reservoir has not been included as it is expected that enhancement of lands along the periphery of the proposed reservoir will offset any tax loss on inundated areas. Overall tax revenues will tend to increase due to construction of the recommended project, based on increased value of property through removal of the flood threat, and the stimulation of new construction in the flood-prone areas. No detailed estimate of this increase has been made as it will result from (a) the project; (b) increased economic activity in the area induced by population and industrial growth and (c) improved access by new highway construction. An estimate of costs for the relocation of State Route No. 10 and intersecting local roads has been included in the analysis.

11. ALTERNATIVE PROJECTS

An evaluation of all the alternate plans considered showed that they could not be economically justified and in many instances did not offer opportunities for full development of the

available resources. The use of a major channel improvement or diversion in lieu of an upstream reservoir was found to be impractical due to the disruption of existing facilities in the heavily built up flood plain areas. Other alternate proposals, including modification of an existing dam and channel work on the Ashuelot River, were found to be either impractical or far more costly than the recommended plan.

TABLE NO. 1 - ATTACHMENT II

COMPARISON OF PROJECT COSTS AND BENEFITS

	50 Years	100 Years
Construction Expenditures	$1,377,000	$1,377,000
Annual Charges		
Interest & Amortization	54,800	45,100
Operation & Maintenance	11,400	11,400
Major Replacements	500	1,200
TOTAL ANNUAL CHARGES	$ 66,700	$ 57,700
Annual Benefits		
Flood Control	$ 112,300	$ 113,600
Water Supply	23,500	20,100
Recreation	33,700	32,000
TOTAL ANNUAL BENEFITS	$ 169,500	$ 165,700
Benefit-Cost Ratio	2.5	2.9

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TABLE 2 - ATTACHMENT II

ALLOCATIONS OF COST FOR BEAVER BROOK DAM

	Economic Life - 50 Years				Economic Life - 100 Years			
	Flood Control	Water Supply	Recreation	Total	Flood Control	Water Supply	Recreation	Total
SEPARABLE COSTS - REMAINING BENEFITS METHOD	$	$	$	$	$	$	$	$
1. Annual Benefits	112,300	23,500	33,700	169,500	113,600	20,100	32,000	165,700
2. Allocation of Costs								
a. Annual economic costs	28,000	14,600	24,100	66,700	23,300	12,100	22,300	57,700
b. Annual O&M and replacement costs	3,700	1,500	6,700	11,900	3,700	1,800	7,100	12,600
c. Construction expenditures in specific facilities	0	20,000	103,000	123,000	0	20,000	103,000	123,000
d. Construction expenditures in joint use facilities	610,000	309,000	335,000	1,254,000	599,000	294,000	361,000	1,254,000
e. Total construction expenditures (First Cost)	610,000	329,000	438,000	1,377,000	599,000	314,000	464,000	1,377,000
f. Benefit - Cost Ratio	4.0	1.6	1.4	2.5	4.9	1.7	1.4	2.9
PRIORITY OF USE METHOD 1/								
1. Annual Benefits	112,300	23,500	33,700	169,500	113,600	20,100	32,000	165,700
2. Allocation of Costs								
a. Annual economic costs	37,800	19,600	9,300	66,700	32,100	16,700	8,900	57,700
b. Annual O&M and replacement costs	4,400	2,300	5,200	11,900	4,600	2,500	5,500	12,600
c. Construction expenditures in specific facilities	0	20,000	103,000	123,000	0	20,000	103,000	123,000
d. Construction expenditures in joint use facilities	839,000	415,000	0	1,254,000	840,000	414,000	0	1,254,000
e. Total construction expenditures (First Cost)	839,000	435,000	103,000	1,377,000	840,000	434,000	103,000	1,377,000
f. Benefit - Cost Ratio	3.0	1.2	3.6	2.5	3.5	1.2	3.6	2.9
INCREMENTAL COST METHOD 2/								
1. Annual Benefits	112,300	23,500	33,700	169,500	113,600	20,100	32,000	165,700
2. Allocation of Costs								
a. Annual economic costs	56,500	900	9,300	66,700	48,000	900	8,800	57,700
b. Annual O&M and replacement costs	6,600	100	5,200	11,900	6,900	300	5,400	12,600
c. Construction expenditures in specific facilities	0	20,000	103,000	123,000	0	20,000	103,000	123,000
d. Construction expenditures in joint use facilities	1,254,000	0	0	1,254,000	1,254,000	0	0	1,254,000
e. Total construction expenditures (First Cost)	1,254,000	20,000	103,000	1,377,000	1,254,000	20,000	103,000	1,377,000
f. Benefit - Cost Ratio	2.0	26.1	3.6	2.5	2.4	22.3	3.6	2.9

1/ Priority for assigning remaining costs (1) Flood Control; (2) Water Supply; (3) Recreation

2/ Flood Control considered the basic function to which all remaining costs are assigned.

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